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High-Tension Transmission Supply

MODERN PLANT OF THE CENTRAL ILLINOIS PUBLIC SERVICE CO. AT KINCAID SERVES LARGE TERRITORY; UNIQUE COAL HANDLING AND STORAGE METHODS EMPLOYED

WITH THE INCREASED RELIABILITY and greater economy of power-station generating machinery and the development of high-tension transforming, control and transmitting equipment has come the present-day public service corporation supplying those smaller communities heretofore unable to enjoy the advantages and conveniences of electric service for light and power. Many towns and villages either without previous service or desiring to eliminate local plants giving unsatisfactory service on account of inefficient operation are also turning to these companies for their supply of electric energy. As a consequence, high-voltage transmission lines interconnected and fed by generating plants advantageously located with reference to load and fuel and water supply are spread netlike over many sections of the country.

Exemplifying this is the system of the Central Illinois Public Service Co., serving 131 communities in central and southern Illinois not only with electricity but also gas, water, ice, heat and electric railways. And in addition to the electric current used for domestic and manu-

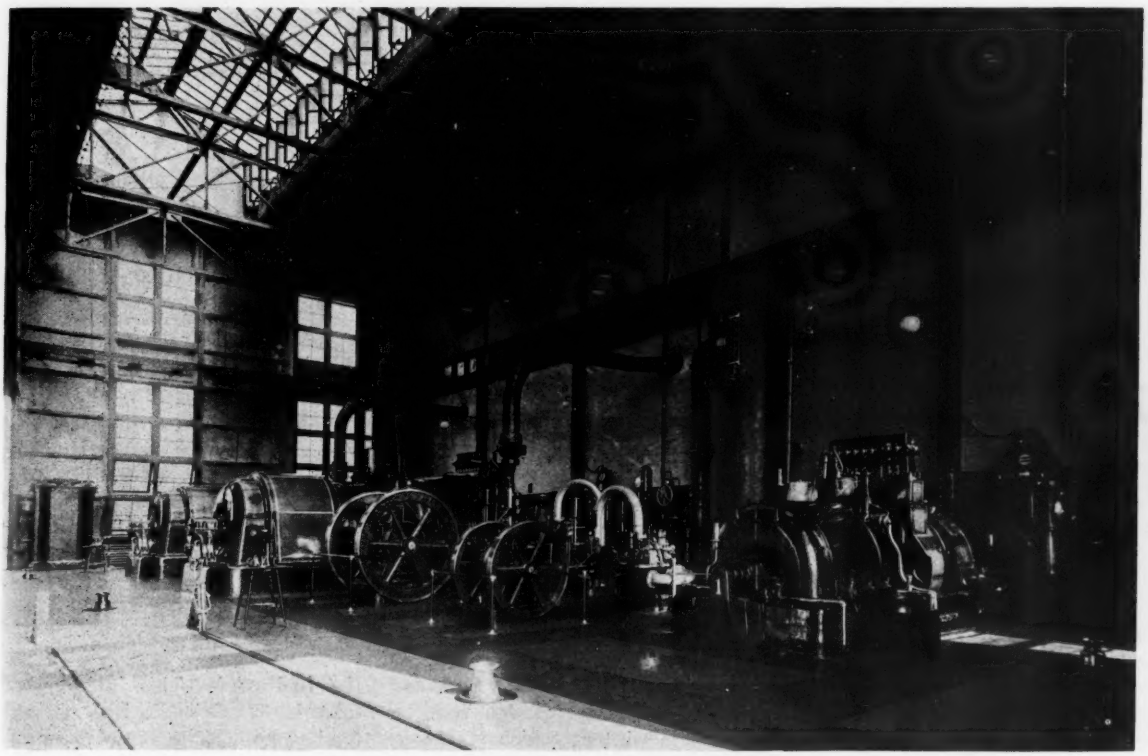


FIG. 1. INTERIOR OF TURBINE ROOM, KINCAID POWER STATION

facturing purposes, much is consumed by coal mines and drainage developments in that district, which with their diversified off-peak demands have aided materially in increasing the system load factor 54 per cent within the 3-yr. period from 1913 to 1916. According to late

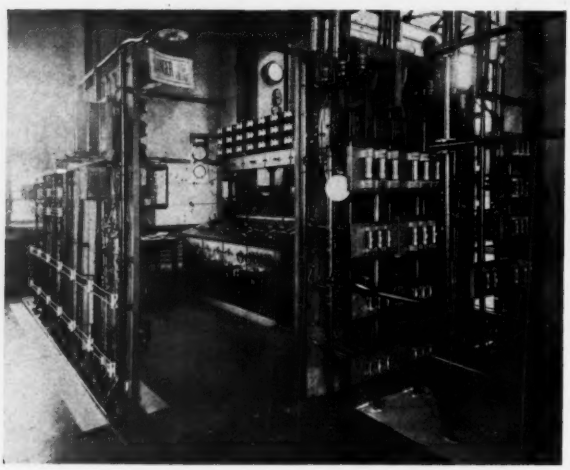


FIG. 2. CONTROL BOARDS, KINCAID POWER STATION

reports, the company now serves a total coal mining load of 1076 hp. and a total reclamation pumping load of 2365 hp.

With an original installation of 50 miles of transmission lines, there are now in operation 882 miles of these lines, current being supplied by 13 central stations owned by the company (10 additional in reserve), 7 others under contract to supply emergency service in-

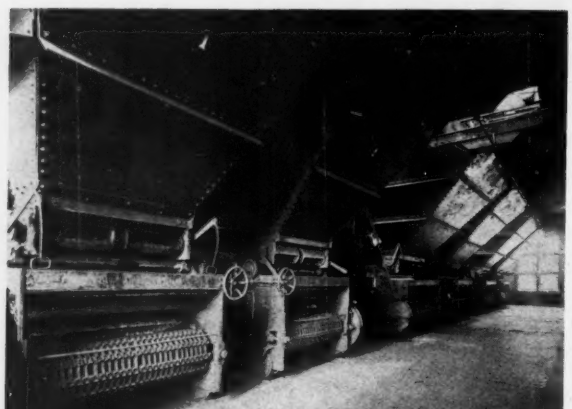


FIG. 3. EACH BOILER IS EQUIPPED WITH CHAIN GRATE STOKER AND INDIVIDUAL COAL BUNKER

cluding the hydro-electric plant of the Mississippi River Power Co. at Keokuk, Ia. Under normal conditions, however, the only service sources employed to feed the main transmission system are the Keokuk plant and the company's generating station at Kincaid. The Mattoon and three other smaller stations are operated in winter only for the supply of steam to the local central heating system. From its own stations and through its contracts for the purchase of power, the company has now available a total of 50,000 hp.

The connected load in 1912 was 21,000 kw. and in 1916, 53,000 kw., an increase of nearly 152 per cent; in 1913 the total output in kilowatt-hours was 16,000,000 and in 1916 40,000,000 kw.-hr., an increase of 150 per cent.

KINCAID STATION

CLOSE PROXIMITY to the system load center, a convenient and abundant coal supply and a satisfactory water supply were undoubtedly governing factors in the selection of the site of this plant which is located about 1 mile east of Kincaid on the Sangamon River and adjoining the right-of-way of the Chicago & Illinois Midland Railroad leading to Taylorville.

As shown in the accompanying illustrations, the building which consists of a framework of structural steel filled in with concrete and red-pressed brick on the outside is laid out along the general lines employed in

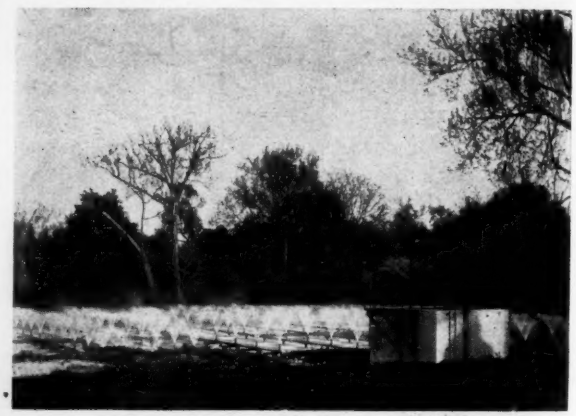


FIG. 4. CONDENSING WATER IS COOLED BY BEING PASSED THROUGH 96 2½-IN. SPRAY HEADS

the modern large central station. The south section contains the boiler room, the middle section the turbine room and the north section the switch house. Each of these sections has a basement and to provide for possible future growth and extension of the station, the east wall is of but a temporary nature, being built up of metal lath and concrete which may be readily removed without interfering with any portion of the main structure. Overall dimensions of the building are 160 ft. by 90 ft. on the turbine room side, and 102 ft. on the boiler room side.

Interior walls are painted white, door and window frames light green, all iron work black, the floors gray and the piping and machinery a dark green.

A 30-ton electrically-operated Toledo crane and a siding spur of the Chicago & Illinois Midland Railroad extending into the turbine room afford exceptional facilities for the handling of heavy machinery.

IN THE BOILER ROOM

SCREENINGS is the fuel used. This is brought in gondola cars from mine No. 7 of the Peabody Coal Co., which is adjacent to the plant. The cars are run into the boiler room onto a track placed above a concrete

storage bin 24 by 12 ft. deep and 102 ft. long and having a capacity of 1200 tons; a short section is at present reserved for ashes. When cars not fitted with dumping bottoms are used for delivery, the coal is removed either to the storage bin or to the bunkers above by means of a 2-yard clam-shell bucket attached to the lift of a regular electrically-operated service crane capable of traveling the full length of the boiler room. While suspended, each bucket of coal is weighed by a Howe track scale.

Contrary to general current practice, each boiler is fitted with its individual steel coal bunker, those serving the 500-hp. units having a capacity of 20 tons each and those serving the 350-hp. boilers having a capacity of 15 tons each. The construction and method of supporting these bunkers is shown in Figs. 3 and 8.

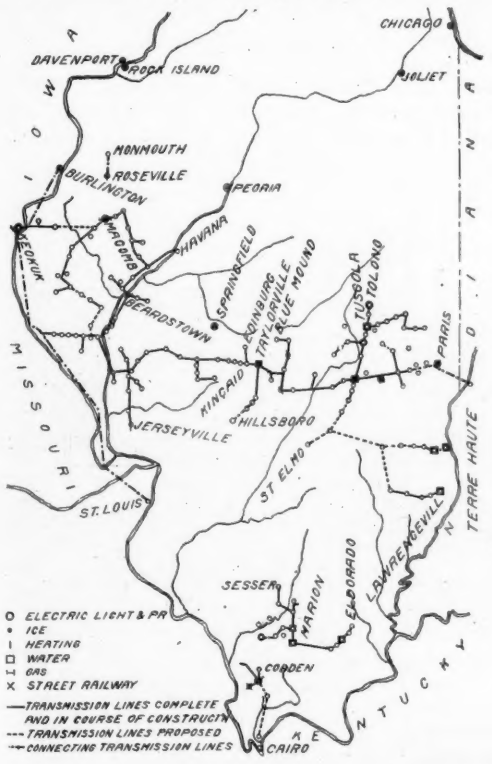


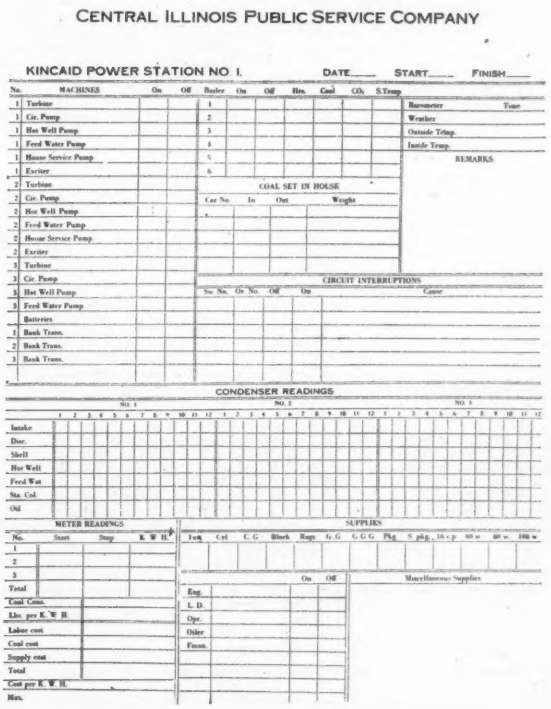
FIG. 5. TERRITORY SERVED BY CENTRAL ILLINOIS PUBLIC SERVICE CO.

Ashes dumped from the grates are deposited in a receiving chamber contained within the boiler setting foundation, whence they are raked into cars of an industrial railway and wheeled to the ash pit. This is emptied at regular intervals, the ashes being placed in railroad cars and hauled away. Much of this unnecessary handling will be eliminated, however, in the near future, as at the time of writing a steam jet ash conveyor was being installed. As soon as this is in operation, it is the intention of the management to use the pit in the boiler room exclusively for submerged coal storage.

Four 500-hp. and 2 350-hp. B. & W. horizontal water-tube boilers equipped with chain-grate stokers and superheaters of the same make comprise the steam generating equipment. These boilers, which have 5000 and 3500 sq. ft. of heating surface each respectively, are of the 3-pass type, vertically baffled and are installed with the bottom of the front tube header about 10 ft. above the boiler room floor. The pressure normally carried is 200 lb. gage with the steam superheated 150 deg. F., giving a working temperature of approximately 538 deg. F.

Power for the operation of the stokers which are driven by a line shaft extending along the boiler fronts is ordinarily furnished by a 9-hp., 220-v., alternating-current induction motor, while a 10 by 12-in. vertical high-speed steam engine is held in reserve for emergency.

A single 200-ft. reinforced concrete stack lined with fire brick and having a diameter of 13 ft. is connected to the various boiler furnaces by means of a steel-plate fire-brick-lined breeching carried on the roof of the boiler room so as to save head room and avoid interference with piping. The breeching is of tapering section and has


CENTRAL ILLINOIS PUBLIC SERVICE COMPANY

KINCAID POWER STATION NO. 1. DATE____ START____ FINISH____

No.	MACHINES	On	Off	Boiler	On	Off	Hrs.	Coal	CO_2	S.Temp
1	Turbine			1						
1	Cir. Pump			2						
1	Hot Well Pump			3						
1	Feed Water Pump			4						
1	House Service Pump			5						
1	Exciter			6						
2	Turbine									
2	Cir. Pump									
2	Hot Well Pump									
2	Feed Water Pump									
2	House Service Pump									
2	Exciter									
3	Turbine									
3	Cir. Pump									
3	Hot Well Pump									
3	Feed Water Pump									
	Batteries									
1	Bank Trans.									
2	Bank Trans.									
3	Bank Trans.									

Barometer Time
Weather
Outside Temp.
Inside Temp.
REMARKS

COAL SET IN HOUSE

Car No.	In	Out	Weight

CIRCUIT INTERRUPTIONS

Sw. No.	Gr. No.	Off	On	Cause

CONDENSER READINGS

	No. 1												No. 2												No. 3											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Intake																																				
Disc.																																				
Shell																																				
Hot Well																																				
Feed Wat																																				
Sta. Col																																				
Oil																																				

METER READINGS

No.	Start	Stop	K. W. H.
1			
2			
3			
Total			
Coal Cons.			
Lbs. per K. W. H.			
Labor cost			
Coal cost			
Supply cost			
Total			
Cost per K. W. H.			
Max.			

SUPPLIES

Tech	Cyl	C. G	Block	Rags	G. G	G. G. G.	Pkg.	S. pkg., 16 c.p.	60 w.	40 w.	100 w.

	On	Off	Miscellaneous Supplies
Eng.			
L. D.			
Opr.			
Oiler			
Firem.			

FIG. 6. OPERATING REPORT BLANK AS USED IN KINCAID STATION

an outlet area of 160 sq. ft., or 0.059 sq. ft. per each nominal connected boiler horsepower.

Each boiler is provided with a Defender draft gage indicating the draft above the fires and that in the last pass; a sample of the flue gases is analyzed for its CO_2 content once every 24 hr. by means of a Defender analyzer.

Piping Systems

Water for all purposes is taken from the south fork of the Sangamon River through an intake supplying a concrete crib located approximately 125 ft. east of the plant. This crib in turn connects with and supplies water to a cooling pond and by means of a concrete tunnel to a cold well in the plant from which the pumps

draw their supply. Discharge from the condensers may be returned to the river or when, due to warm weather, the circulating water is at an unsuitably high temperature it is cooled in the spray pond located 200 ft. east of the plant. This pond, which has an average length of 400 ft., an average width of 150 ft. and a maximum capacity of 17,500 gal. per minute, is provided with a spraying equipment consisting of 96 2½-in. Schutte and Koerting spray nozzles arranged in 8 rows of 12 each. The approximate cooling effect obtained by the use of the pond is 8 deg. F. above atmospheric temperature.

Condensate from the condensers is used exclusively for boiler feed purposes and any makeup which may be required is taken from a large concrete reservoir which receives all cooling water returns from the transformers, turbine bearings and seals and the clean drips from the various pipe lines. All such makeup, however, before being used is first delivered to a settling tank having a diameter of approximately 5 ft. and a length of 10 ft., and before going from here to the hot well in the boiler room basement is passed through a pressure filter, the filtering material in which consists of 4 ft. of gravel and 3 ft. of fine sand. One of two 7½ by 10¼ by 10-in. Worthington reciprocating pumps is employed to handle the makeup.

The boiler feed after passing through one of 2 vertical Stillwell feed-water heaters, each having sufficient capacity to heat 100,000 lb. of water per hour from a temperature of 70 deg. F. to 200 deg. F. is delivered to the boilers through a short header running along the boiler room wall, the pumping equipment for this purpose consisting of two 12 by 8 by 18-in. and one 14 by 8½ by 10-in. Worthington pumps. The larger of these is used for emergency service and boiler washing purposes only.

Special precautions have been taken to guard against possibility of shut down due to inability to supply the boilers with sufficient feed by having duplicate header branches, one being carried overhead and the other under the boiler room floor. Both, however, terminate in a single feed inlet under manual control.

Each boiler drum and superheater is provided with its individual pop safety valve, the former having 4 and 3-in. valves according to the size of the boilers, while those on the superheaters are 2½ in.

Steam is taken from the boilers through branch lines each of which is fitted with a main stop valve and a nonreturn stop valve of Edwards make, and delivered to a 12-in. main header carried along the boiler room wall about 10 ft. above the floor and readily accessible

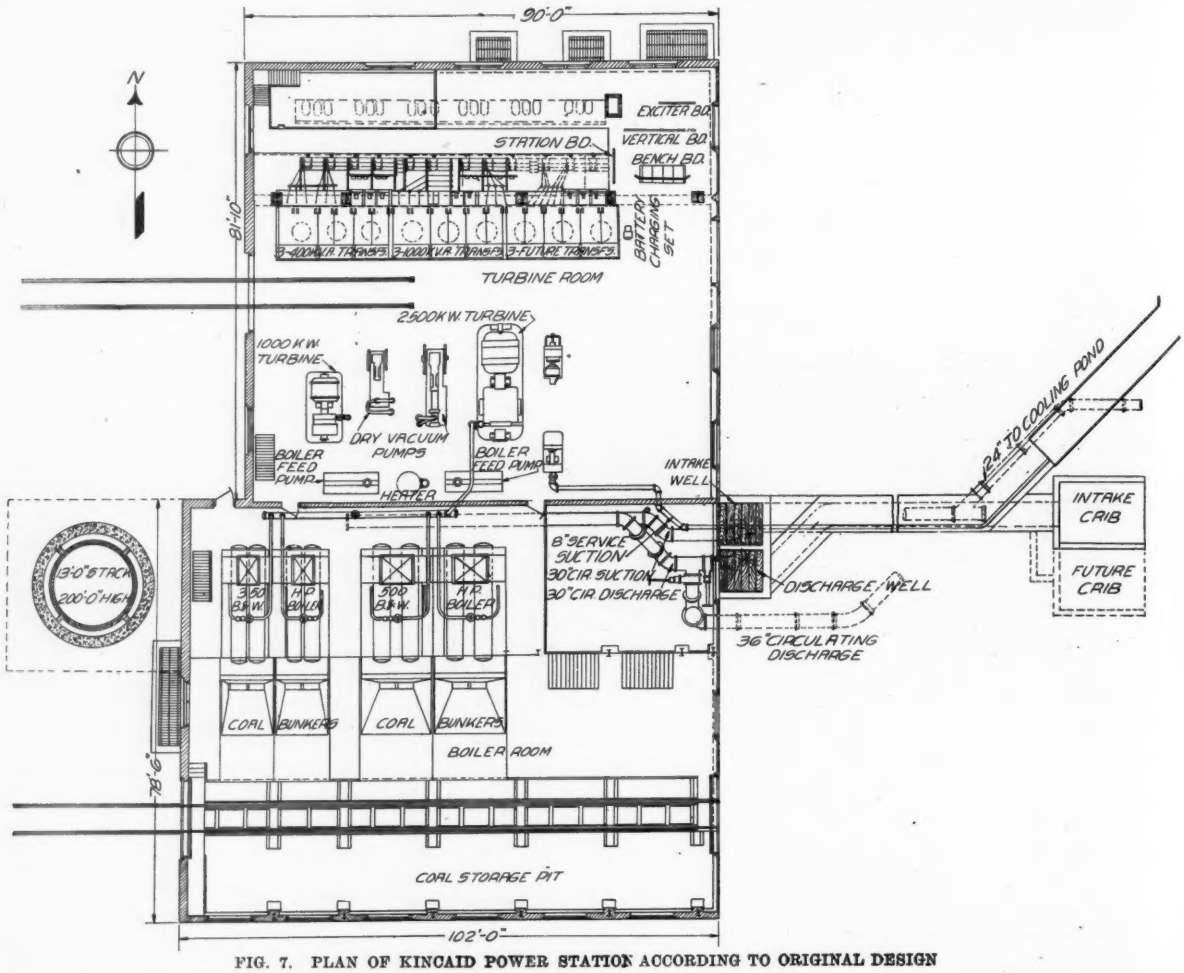


FIG. 7. PLAN OF KINCAID POWER STATION ACCORDING TO ORIGINAL DESIGN

by means of iron ladders and gangway. The turbine supply branches are each 8 in. in diameter except that for the smaller unit which is 6 in.

Individual atmospheric exhaust risers extending to the roof of the boiler house and fitted with 24-in. Crane relief valves for the large units and a 16-in. valve of the same make for the 1000-kv.a. machine are provided.

All clean drips are returned to a tank having a diameter of 2½ ft. and a length of 5 ft. from which they are pumped directly to the boilers by a 6 by 4 by 8-in. Platt hydraulic pump. Dirty drips are piped to a well provided for the purpose whence they are removed by a vertical centrifugal pump driven by a 5-hp. General Electric induction motor under automatic float control.

Except in minor instances, Edwards valves are employed.

Prime Movers

Current is supplied from Kincaid by 3 2300-v., 60-cycle, 3-phase General Electric turbine generating sets, two of which are rated at 2500 kv.a., and the other at 1000 kv.a. These sets are operated condensing, each having its individual equipment for that purpose located in the basement of the turbine room except the rotary dry vacuum pumps which, as shown in Fig. 1, are placed near the generating sets they serve on the turbine room floor.

The condensers are of the Worthington surface type, those employed in conjunction with the 2500 kv.a. units having 7000 sq. ft. of condensing surface and the smaller one 3200 sq. ft., or 2.8 and 3.2 sq. ft. respectively per kilovolt-ampere generator rating. Circulating water is passed through 1-in. brass tubes being delivered to the condensers by individual Worthington noncondensing steam-turbine-driven centrifugal pumps, the larger ones having a capacity of 7000 gal. per minute each and the smaller set 2500 gal. per minute. Two 10 by 19 by 18-in. and one 8 by 16 by 12-in. Laidlaw-Dunn-Gordon rotative dry vacuum pumps are employed to care for the entrained air and non-condensible gases.

Excitation for the main generating units is ordinarily furnished by a 75-kw., 125-v. General Electric direct-current generator driven by a 115 hp. induction motor; for emergency and starting purposes and an exciter of equal capacity but driven by a Curtis steam turbine has been installed and which like all other plant auxiliaries is operated noncondensing, the exhaust being employed to heat the boiler feed.

Electrical Equipment

All electrical transforming, switching and control equipment except the engineers' control panels, one of which is conveniently located near each generating unit, is contained in that part of the station which may properly be referred to as the switch house.

Current from the generators is delivered to the bus bars through the medium of remotely-controlled electrically-operated oil switches and then, except for the house service and the 2300-v. Kincaid service, and the 4600-v. Edinburg Line is stepped up to 33,000 v. by delta-delta connected water cooled transformers placed in a pit in the engine room. Three 25-kv.a. 2300 to 4600-v. air-cooled transformers supply current to Edinburg, a few miles distant. Brass tubing is used for high-tension conductors and all of the station electric equipment is amply protected from the effects of lightning discharges by electrolytic arresters connected to each outgoing line.

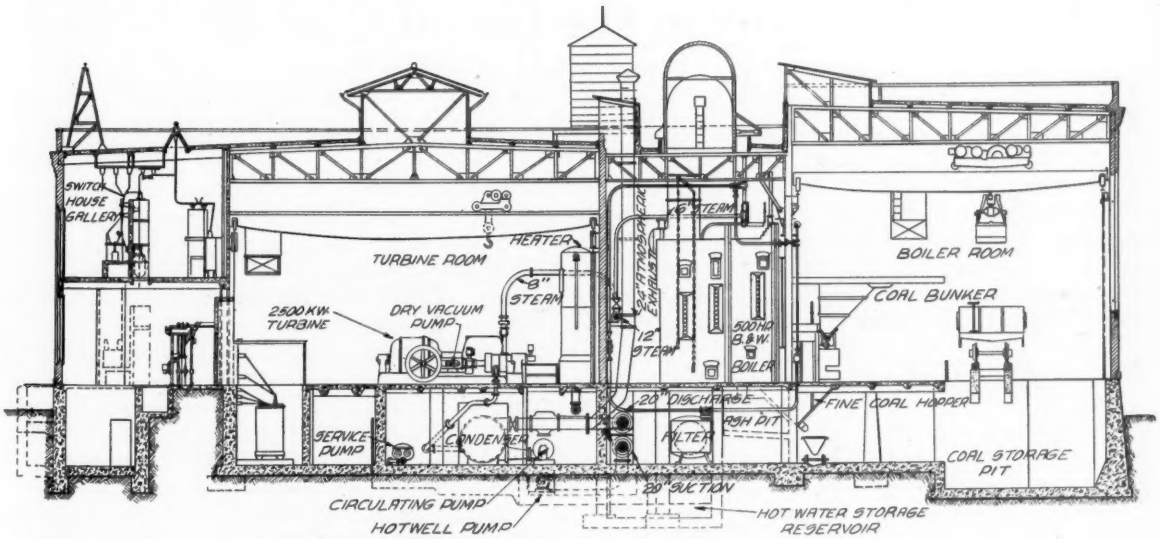


FIG. 8. SECTIONAL ELEVATION OF KINCAID POWER STATION

Arrangement of the control boards, of which there are 4, is shown in Fig. 2. The bench board, as may be seen, is built up of 4 sections or panels for exciter and main generator control; the vertical 6-panel board at the left is for the east and west high-tension lines, the 2300-v. Kincaid line, the 4600-v. Edinburg line and transformer control and station service, while 2 other boards have been installed to carry the generator field and house service switches and circuit breakers.

Appreciating the possibility of a shut down spite of all precautions which may be taken in the design, construction and operation of a power plant, and as current for the control of the generator and high-tension

switches is normally furnished by a 5-kw., 125-v. motor-generator set which in turn depends upon the main generators for its supply of current, a 78 amp.-hr. storage battery has been installed. This battery, which consists of 62 cells placed on racks in a battery room on the second floor of the switch house is for emergency service only. Connections are such that with a service voltage drop, a double-throw switch provided with a low-voltage release will automatically transfer both switch-control and station-lighting service onto the battery, thus giving the operators full control over the switching equipment under the most adverse conditions, and thereby making it possible to restore the service within the shortest possible time. As the bus voltage again approaches its normal value, the double throw switch will reverse automatically and switch control and lighting circuits be again connected to their regular source of supply and the battery cut out.

In addition to the storage battery, the second floor of the switch house contains the station service transformers, electrolytic lightning arresters, disconnecting switches and a concrete switch-cell structure. One side of this is divided into 6 compartments, each containing a set of 3 3500-v. General Electric solenoid-operated oil switches used for the control of the various transformer banks, and out going transmission line. On the opposite side of this structure are smaller compartments containing potential transformers and covered by fireproof hanging doors.

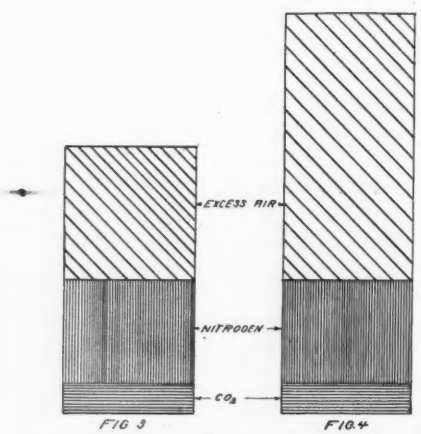
Operating Records

Complete plant records, as shown reproduced in Fig. 6, are maintained whereon all station activities are noted for future reference. These records not only indicate the running time of the various units and their auxiliaries, but also give such other information as total amount of coal received and consumed per day, per hour, per boiler and per kilowatt-hour; condenser temperatures; circuit interruptions; supplies used and weather conditions.

Economy in the Use of Coal--II

Losses Due to Excess Air and Incomplete Combustion; Interpretation of CO_2 Record. By A. Bement

THE matter of fuel loss in the refuse having been disposed of in a previous article, a discussion of the combustion losses may be taken up, and their departure from the ideal performance of Table No. 1, page 113, Jan. 15 issue, explained. The matter of air supply should have first attention. The combustion process can only use about 150 cu. ft. of air for each pound of coal, and any amount greater than this remains unused; it is simply present without doing any work. The air supply is composed of 79 parts nitrogen and 21 of oxygen. In combustion of coal about 2.5 parts of the oxygen would enter combination with the hydrogen forming water, which cannot be measured in an analysis of the gases. The 18.5 parts of oxygen enter combination with the carbon of the coal forming CO_2 which is easily measured by analysis and upon which is based the successful operation of the automatic CO_2 analyzer and recorder. While 150 cu. ft. of air is sufficient for the combustion of a pound of coal, it is desirable to have a small amount in excess for reasons to be explained later.



FIGS. 3 AND 4. DIAGRAMS ILLUSTRATING THE RELATION OF GASES OF COMBUSTION TO AIR IN EXCESS IN THE FURNACE

As will be observed, the ideal performance shown in Table No. 1 is based on 17 per cent CO_2 instead of 18.5, thus allowing a small amount of surplus air. The matter of excess air is illustrated in Fig. 3 where the horizontal cross hatched area represents the volume of oxygen which has been changed to CO_2, and the vertical hatched area that of the residual nitrogen, both of which represent and are practically of the same volume as the 150 cu. ft. of air. The area of equal magnitude with diagonal hatching lying just above, represents excess air which has played no part in the combustion process, yet it is as large a volume as that part which performed all of the work. Likewise Fig. 4 illustrates the matter with air 200 per cent in excess, or, in other words, 450 cu. ft. being supplied with all the work being done by only 150. The foregoing makes clear the principle upon which the matter of air supply is based, and illustrates how a knowledge of the CO_2 indicates its amount, which is further shown in Fig. 5. Knowing the CO_2 in the combustion gas, the amount of excess air may be determined, which reaches great magnitude as the CO_2 gets low.

Economic Significance of Excess Air

Having considered the fact of excess air, it is in order to examine the economic significance of it. The heat evolved from the burning of the coal is expended in heating the gases in the furnace, and these gases in turn give up, or transfer, this heat to the boiler or other object to be heated. The temperature at which this heat is evolved is of supreme importance, as an efficient trans-

fer of heat is dependent on a high temperature of combustion, because the rapidity and amount of the transfer is dependent on the elevation of temperature, or in other words, a hot fire is most efficient.

It is, of course, apparent that the heat in one pound of coal will raise the temperature of 150 cu. ft. of gas to a greater elevation than it will 300 or 450 cu. ft. Therefore the small air supply produces a hot fire, and the hot fire is effective in heating the boiler or other appliances to which heat is directed. Figure 6 illustrates this matter in boiler performance. The figures at the top of the diagram show CO_2 and those at the bottom of the diagram show corresponding furnace temperatures, or in other words, temperatures of combus-

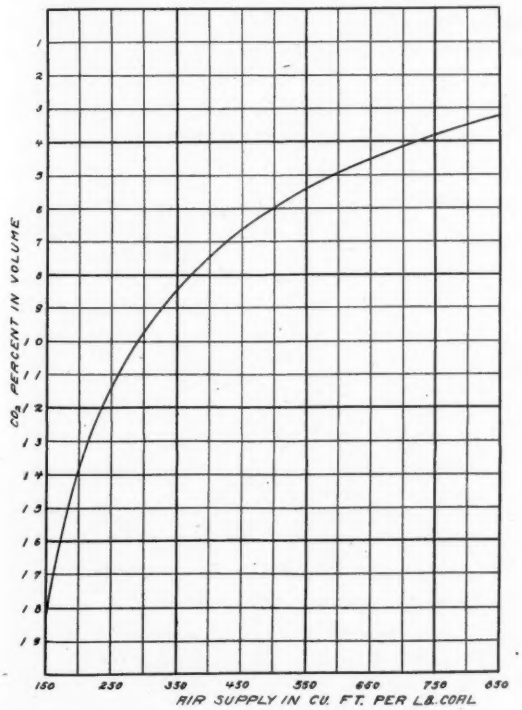


FIG. 5. CURVE SHOWING THE RELATION OF THE CO_2, AND VOLUME OF THE AIR SUPPLY

tion. The curves within the diagram bearing designations of from 100 to 1000 deg., represent a range of temperatures at which gases might leave boilers. For example, if the CO_2 is 6 and the temperature of escaping gases 500 deg., reading down from the CO_2 to the temperature line, then directly to the left shows efficiency at 60 per cent, or if the furnace temperature for this condition, 1250 deg. be shown, reading up to the final gas temperature of 500 deg., then to the left, shows as before an efficiency of 60 per cent.

Excessive air supply causes the largest heat loss that can occur in connection with combustion, it is the only one which can be as high as 100 per cent; that it can be this high is proven by the fact that a banked fire may and does burn away without making any steam in the boiler, in fact in some instances it may momentarily rise to above 100. Sometimes when a hand fired furnace is being cleaned, the CO_2 may go down to 2 per cent, while the gases leave to the chimney at 550 deg., the air entering the furnace being heated by the still hot brickwork.

The magnitude of the excess air loss compared with the other combustion losses is shown graphically in Fig. 7. A bituminous coal is represented, and it is

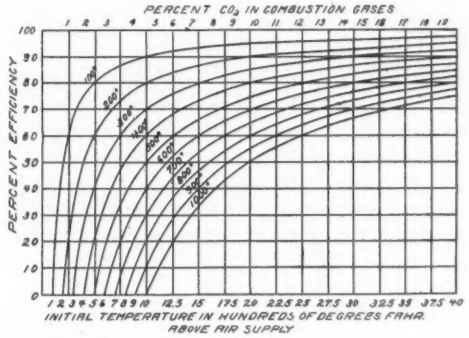


FIG. 6. DIAGRAM ILLUSTRATING EFFICIENCY IN HEAT TRANSMISSION, WITH A WIDE RANGE IN FURNACE AND CHIMNEY GAS TEMPERATURE

assumed that the losses of combustible in the refuse, carbon burned to CO and escaping volatile matter, could occur to the extent of 100 per cent. Plotted with these, the curve of loss by excess air arrives at 100 per cent loss before the maximum, or, in other words, zero CO_2 is reached. As a matter of fact, however, it would

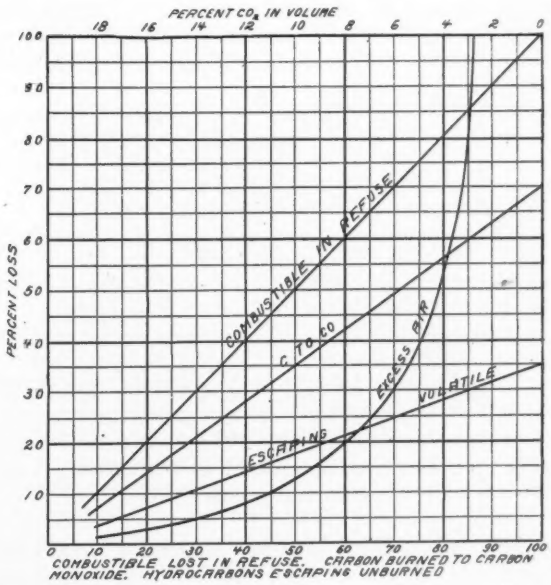


FIG. 7. DIAGRAM ILLUSTRATING COMBUSTION LOSSES AT THEIR THEORETICAL MAXIMUM

be impossible for all of the volatile matter to escape without the combustion of some of it, or for all of the carbon to be burned to carbon monoxide. Neither would it be possible for all of the coal to get into the ash pit, because in such an event there would be no fire at all.

But these assumptions in the diagram help to illustrate the comparative magnitude of the excess air loss at its maximum; so large, in fact, as to cause the serious incomplete combustion losses to be often overlooked.

Incomplete Combustion

Excess air loss having been described, an examination of the incomplete combustion losses is in order. These losses are included under two heads. The first is

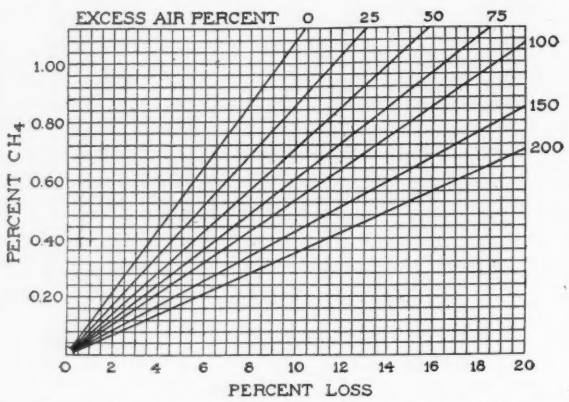


FIG. 8. DIAGRAM SHOWING EFFECT OF METHANE IN COMBUSTION GASES

what may properly be called incomplete, or partial combustion; this process is the formation of carbon monoxide, which signifies that one portion of carbon has combined with one of oxygen. The heat production of this process is but 30 per cent of the complete combustion, in which one partion of carbon unites with 2 portions of oxygen, forming carbon dioxide, expressed by the symbol CO_2. That under the second head is more

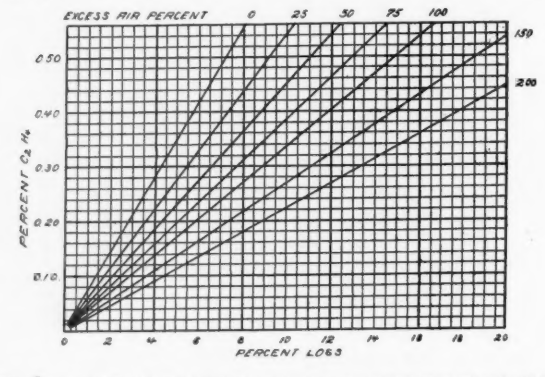


FIG. 9. DIAGRAM SHOWING EFFECT OF ETHYLENE IN COMBUSTION GASES

properly designated as a lack of combustion, or in other words, as a failure to combine, than as an incomplete combustion process.

Incomplete combustion proper, the formation of CO, when it occurs, is a loss of small magnitude, yet, as it may be determined with comparative ease, while the loss of escaping volatile combustible matter cannot be determined by any practical method of analysis at all, has led to a more or less general belief that the incomplete combustion loss is entirely embraced by the formation of CO_2. As a fact, however, the loss by escaping combustible which may occur, is much greater than that which can be produced by the formation of carbon monoxide. To a failure to take into consideration this fact, is to be attributed the only practical difficulty in the utilization of the CO_2 recorder, and when this is realized the use of the instrument becomes entirely effective. These gases are of various compositions, many of which are unknown. Methane and Ethylene are two of the more common forms and Figs. 8 and 9 serve to illustrate what small percentages are required to produce serious losses in different volumes of combustion gases as indicated by the varying amounts of air in excess.

Heat Balance and CO_2 Record

Having indicated the different ways that the combustion process may go wrong, the matter may be still further made clear by the presentation of an hypotheti-

TABLE II SHOWING COMPARATIVE DISTRIBUTION OF HEAT IN STEAM PRODUCTION

	Percentage distribution of heat with good and poor conditions.	
	Good condition	Poor condition
1. Loss in the dry hot chimney gas..	9.63	19.00
Loss in the moist hot chimney gases—		
2. Due to the combustion of available hydrogen.....	3.50	3.15
3. Due to the presence of water of combination in the coal.....	0.50	0.50
4. Due to the presence of moisture in the coal.....	0.05	0.05
5. Due to the presence of vapor in the air supply.....	0.25	0.54
6. Loss by sensible heat in the ashes	0.07	0.16
7. Loss by radiation from the boiler and its setting	1.50	1.50
8. Loss by carbon monoxide.....	0.00	1.00
9. Loss by escaping hydrocarbons..	0.00	9.24
10. Loss by fuel in the ashes.....	0.00	5.00
Total loss	15.50	40.14
11. Heat available for making steam	84.50	59.86
Total heat of the coal.....	100.00	100.00

cal heat balance, in which such losses appear, in Table No. II. The good condition employed is copied from Table No. I, the assumption being that the same coal is used under each condition. While the condition in the second column is designated as poor, as a matter of fact it is poor only in comparison with the ideal example in the first column, as it is better than average prevailing practice. From this table it appears that there are 4 preventable losses, one which is readily observable on inspection of the ash pit. From the standpoint of combustion, therefore, there are 3 preventable losses, which in the order of their magnitude are as follows:

1. In the hot gases due to excessive air supply.
2. In the escaping hydrocarbons.
3. In carbon monoxide.

In the adaption of the CO_2 recorder, as a guide for the management of fires, and a means for the recording of performance, these 3 groups must receive consideration, as the question naturally arises, how can the record of CO_2 tell anything about the second or third items? The answer to these questions is something having first significance in the use of the CO_2 recorder, and a special bearing on the only real difficulty experienced by those who are learning the use of the instrument. Taking these groups in their order, we find that the CO_2 recorder readily shows the amount of excess air by means of a record of the CO_2; in fact, this is its strongest point. It, however, does not directly give any indications of the

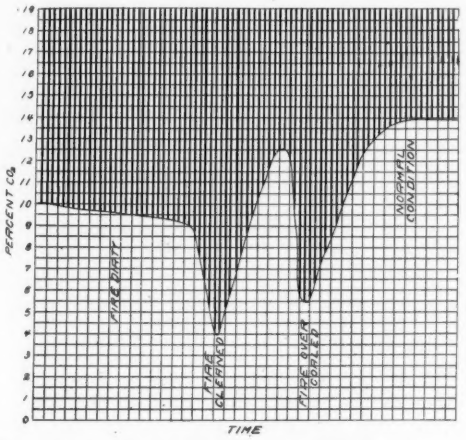


FIG. 10. RECORD OF CO_2 INDICATING CONDITIONS OF INCOMPLETE COMBUSTION, AIR IN EXCESS, ESCAPING HYDROCARBONS AND GOOD COMBUSTION

escaping hydrocarbons, or the carbon monoxide, and it is in this that many have felt that the instrument is inadequate and incomplete. If it were possible and practicable to devise and employ an instrument that would record these two kinds of incomplete combustion losses, then it would be conceded that the instrument is inadequate. But it is neither possible nor practicable to do so. It is impossible by any known practicable laboratory method to determine the escaping hydrocarbons; it is therefore out of the question to expect that any automatic instrument could make a record of these complicated losses. It would be possible to determine and record carbon monoxide automatically, the same as it is done with carbon dioxide, but it would not be practicable, because it would be several times more difficult and expensive, and only give results on a constituent having a significance of only about one per cent of the heat involved, while air supply is easily determined and has a significance of from 10 up to as much as 50 or 60 per cent, in some instances. The CO_2 recorder, however, can and does give, in an indirect manner, information as to the presence of carbon monoxide and escaping hydrocarbons.

This information is based on an observation of associated facts taken together with the CO_2 indication, very clearly illustrated by Fig. 10, which is performance from a sloping grate stoker. As the time approached for cleaning the fire, the CO_2 gradually declined; but as the feed of coal continued in full amount, it is apparent that the drop was not due to excess of air. This taken together with the known fact that there was a continually increasing accumulation of clinker on the grate, makes it apparent that the obstruction of the air supply to the fuel bed, due to the clinker, caused carbon to go to CO instead of CO_2. When the dump grate was opened, and the ash and clinker discharged, there was a great excess of air causing the CO_2 to drop rapidly until the grate was closed, and as the fireman poked coal from the hopper upon the grate, it rose rapidly.

Now it is, of course, apparent without any argument, that the drop in CO_2 at the cleaning of fire, was due to increasing excess of air, and its recovery, and ascent to 12.5, to increasing fuel supply. If when the CO_2 had reached this point, the fireman had stopped, and let the stoker feed automatically, all would have been well; but he had not at that time learned to be guided by the CO_2 indication, and continued to poke down the coal, with the result that before he ceased, CO_2 had fallen to between 5.5 and 6. The reason that it dropped was that such a large amount of carbon escaped in unburned hydrocarbons, that there was not much left to form CO_2. This condition was further proven by the fact of very dense masses of smoke. When the fireman had ceased to poke, CO_2 began to rise till a normal condition was attained, in which it was known that combustion was complete, because the fire was clean and there was no smoke. Thus if the observed facts are connected with the CO_2 there is evidence of carbon monoxide, excess of air, escaping hydrocarbons and normal condition, each unmistakably apparent. This illustrates the principle involved in using the CO_2 determination as an indication of the prevalence of incomplete combustion.

(To be Continued.)

Intrusting Authority to Subordinates

CAN YOU remember the first time that you were intrusted with the complete charge of some piece of work, or care of a part of the plant? How proud and how important you felt! It helped you to accomplish that which was intrusted to you. As soon as you realized that you were given a share of the responsibility in the work of the plant, how you did dig in, and show the chief that you could make good! You knew that he was watching you all the time, and as you made good in each thing that you were given charge of, your rise upon the ladder of success was started. Now that you are pretty well up, and have a chance to trust others with a little authority, do you do it, or do you keep all the authority in your own hands? C. H. WILLEY.

U. S. CIVIL SERVICE COMMISSION announces an examination, Feb. 6, for mechanical draftsman in the Bureau of Yards and Docks, Navy Department, Washington, D. C., at salaries ranging from $3.52 to $6 a day. Competitors will be rated on education, preliminary training and experience, and must have reached their twenty-first birthday. Apply for Form 1312.

Thick Cast Cylinders

CONDITIONS ENTERING DESIGN OF CYLINDERS AND DEVELOPMENT OF FORMULA. BY P. M. GALLO

THERE are various standard formulas for cylinder thickness in general use. Some are applicable to a limited range of pressure, others leave a great deal to the judgment of the designer, and therefore are misleading to the inexperienced.

I have done considerable work in designing of cylinders for all kinds of work and conditions so that I found it profitable to give this matter special thought and arrange it in such shape that anybody can use it on short notice.

One of the first and simplest equations used is:

$$t = \frac{P\,D}{2\,S} \quad \text{.....I}$$

t = thickness in inches.
D = inside diameter, inches.
P = unit working pressure, lb. per sq. in.
S = unit allowable fiber stress of material used, lb. per sq. in.

This equation does not express the true relation of the quantities entering it, but the deviation is so small at low pressures that it is safe to use practically and is preferred on account of its simplicity. If materials were absolutely perfect and conditions could be predetermined accurately, Equation I could be applied as it stands. Unfortunately this is not the case. There is a minimum thickness below which sound castings are not possible; this must be allowed for. Then there is shock, water hammer, probable bending stress, etc. These must be determined and allowed for in each case, as they vary for every condition.

Above a certain pressure Equation I gives results too small, the error increasing rapidly as the pressure increases. This limit varies with the allowable fiber stress of the material. The higher the allowable fiber stress the higher this limit.

The necessary added thickness to allow for sound casting decreases as the diameter increases because the required thickness to stand the pressure from Equation I gradually becomes sufficient that sound castings are possible without any additional metal. For very small cylinders the thickness required for sound castings controls, and will safely carry the working pressure.

A formula which takes care of the amount of added thickness is:

$$t = \frac{(P+100)\,D}{2S} + 0.34\left(1 - \frac{D}{100}\right) \quad \text{.....II}$$

Notation same as before.

"P" is increased by 100 lb. to allow for shock. The quantity $0.34\left(1-\frac{D}{100}\right)$ is the addition for sound casting.

This equation is generally used for cast-iron water pipe, steam fittings, etc., and Equation I is applicable to low pressure only.

For hydraulic or high-pressure cylinder the following equation is commonly used:

$$t = r\left[\left(\frac{S+P}{S-P}\right) - 1\right] \quad \text{.....III}$$

r = internal radius, other notation same as before.

This is Leme's equation for the investigation of guns and expresses nearly the true relations of the quantities entering it. It omits to consider the lateral contraction of elastic materials under stress. This lateral contraction affects the thickness only under high pressures, such as are used in guns, for ordinary hydraulic work this is unappreciable and therefore can be omitted. This equation gives practically the same results on low pressures as Equation I, and consequently needs reconstruction similar to Equation II, so that it may apply to any pressure.

As the pressure increases, the thickness of metal also increases, and consequently the amount added for sound casting can be correspondingly decreased. This equation therefore requires 2 additional factors: one to decrease the added amount of metal as the pressure increases and one to decrease it as the diameter increases.

I have derived the following empirical equation that fulfills these conditions:

$$t = r\left[\sqrt{\frac{S+P}{S-P}} - 1\right] + \frac{S-P}{S}(0.452 - 0.0061D) + \left(\frac{S-P}{S+P}\right)^{5}(0.023D) \quad \text{.....IV.}$$

In the second member of this equation, the first quantity gives the thickness required to stand the pressure. The second quantity varies the added thickness with the variation of the diameter. The third quantity varies the added thickness with variations in pressure.

Both these quantities are functions of the pressure, and are so correlated that the minimum thickness is the minimum thickness possible for sound casting when "P" = O.

There is no allowance made for shock and possible bending stresses; these must be determined to suit each case, as they vary widely and seldom are 2 conditions alike.

This formula can be used for any pressure from 0 lb. up.

As this equation is somewhat laborious to solve, I have constructed a chart which covers general ranges of practice. From this chart any quantity can be quickly determined when the others are known.

Directions for using are given on the chart.

If intermediate stress curves are desired, they are easily obtained. The property of these curves being that the ordinate or vertical distances between curves are directly proportional to the difference of fiber stress represented by these curves, therefore if a stress curve halfway between 8000 and 10,000 is desired, plot points halfway between these curves vertically and draw a smooth line through them and a 9000 lb. stress curve results. If a 2000 lb. stress curve is desired, project the ordinate between the 3000 and 4000 lb. curves vertically below the 3000 lb. curve and draw a smooth line through the points thus found and a 2000 lb. curve results.

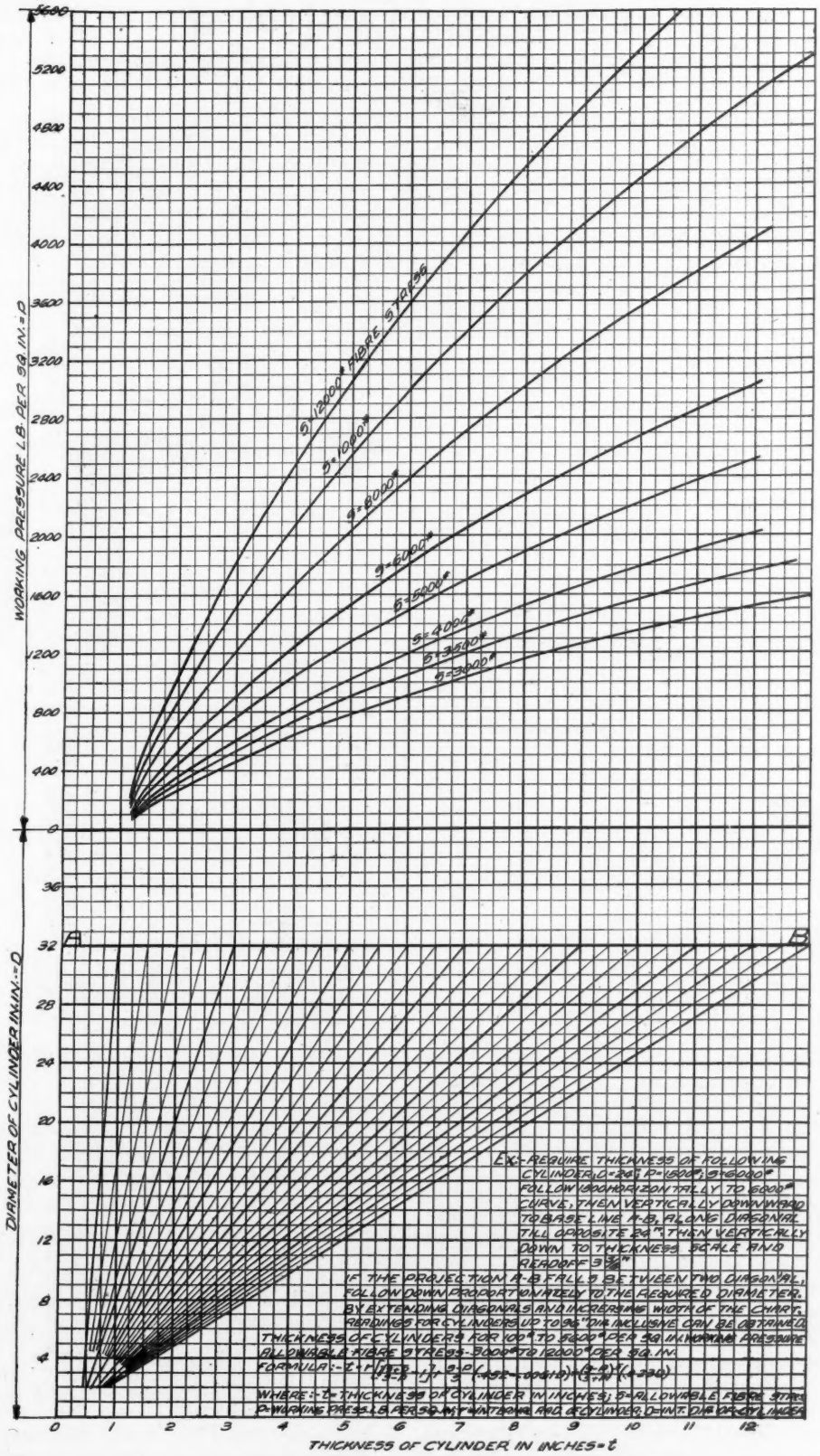

WORKING PRESSURE LB. PER SQ IN.=P
DIAMETER OF CYLINDER IN IN.=D
THICKNESS OF CYLINDER IN INCHES=t
S=12000# FIBRE STRESS
S=10000#
S=8000#
S=6000#
S=5000#
S=4000#
S=3500#
S=3000#
A
B
EX:-REQUIRE THICKNESS OF FOLLOWING CYLINDER, D=26", P=1600#, S=6000#. FOLLOW HORIZONTALLY TO 6000# CURVE, THEN VERTICALLY DOWN AND TO BASE LINE A-B, ALONG DIAGONAL TILL OPPOSITE 26" THEN VERTICALLY DOWN TO THICKNESS SCALE AND READ OFF 3 3/4"
IF THE PROJECTION A-B FALLS BETWEEN TWO DIAGONALS, FOLLOW DOWN PROPORTIONATELY TO THE REQUIRED DIAMETER. BY EXTENDING DIAGONALS AND INCREASING WIDTH OF THE CHART, READINGS FOR CYLINDERS UP TO 96" DIA. INCLUSIVE CAN BE OBTAINED.
THICKNESS OF CYLINDERS FOR 100# TO 1600# PER SQ IN. NORMAL PRESSURE ALLOWABLE FIBRE STRESS 3000# TO 12000# PER SQ IN.
FORMULA:- t = r(√(S+P)/(S-1.3P) - 1) + 0.3(1.08d+0.039)(S+P)/(S-1.3P)+0.039)
WHERE:- t= THICKNESS OF CYLINDER IN INCHES; S=ALLOWABLE FIBRE STRESS IN WORKING PRESS LB PER SQ INCH; P=NORMAL WORKING PRESSURE; d= INT. DIA OF CYLINDER

CHART FOR CALCULATING THICKNESS OF CAST CYLINDERS

Feed Water Control--II

CONTINUATION OF DESCRIPTION OF COMMERICAL TYPES OF FEED WATER REGULATORS GIVING PRINCIPLES OF OPERATION AND DETAILS OF CONSTRUCTION

IN THE SQUIRES Feed Water controller, a heavy cast-iron water column, marked XX on the detailed piping plan, in Fig. 5, is connected at the top and bottom by a series of heavy copper tubes, called the harp. The extreme ends of these copper tubes are connected by means of a rod, turnbuckle and an auxiliary valve, B, having a steam inlet from the harp and 2 outlets, one regulating valve, A, and the other an exhaust.

The harp is held by and connected to a heavy cast-iron column so placed on the boiler that the true water line is as indicated. Consider valve A closed and the water at its true level. As the boiler gives off steam, the water line drops and the harp becomes filled with more steam, causing it to expand, pulling against the spring in auxiliary valve B, causes the pressure in the diaphragm of valve A to be released, and allow more water

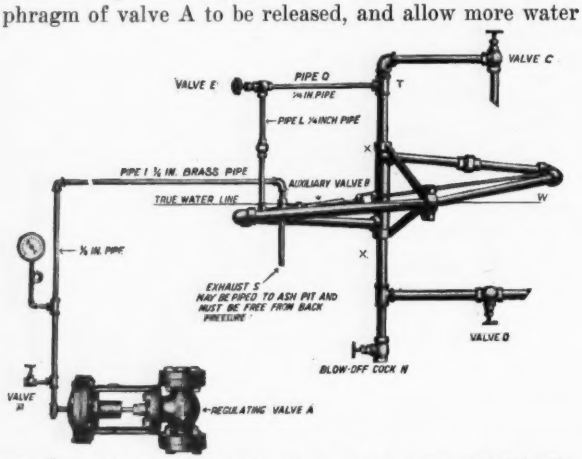


FIG. 5. DIAGRAM OF CONNECTIONS OF SQUIRES REGULATOR

to enter the boiler. This causing the water to rise and consequently filling the copper tube, results in the contraction of the harp, which in turn allows the spring in auxiliary valve B to close the port between the regulating valve and the exhaust. Steam now entering the auxiliary valve from the harp, passes the resistance plug valve and gradually builds up a pressure against the diaphragm of the regulating valve, closing it and shutting off the water. The C. E. Squires Co., of Cleveland, O., manufactures this regulator.

VIGILANT FEED WATER REGULATOR

THREE ESSENTIAL PARTS are employed in the operation of this regulator, illustrated in Fig. 6, which is made by the Chaplin-Fulton Co., of Pittsburgh, Pa. The first is a combination union angle valve nipple, 2, which is screwed into the water column at the middle gage cock opening. From the union of this valve a ⅜-in. pipe connection is made to the top of the chamber of the regulator. A hooded chamber is the second part, and the controlling valve, 6, is the third part.

When the water level in the column is below the opening of the special nipple, steam will enter the chamber of the regulator, and the water in it will be displaced falling through the pipe at its bottom to the level of the water in the water column. The displacement body in the chamber then falls by gravity to the bottom of the chamber, and the counterweighted lever, 5, will rise, holding the actuating valve against its top seat, and the exhaust valve will open to the air at opening 3. There will then be no pressure on the piston of the controlling valve, and the valve will be fully opened to admit water to the boiler.

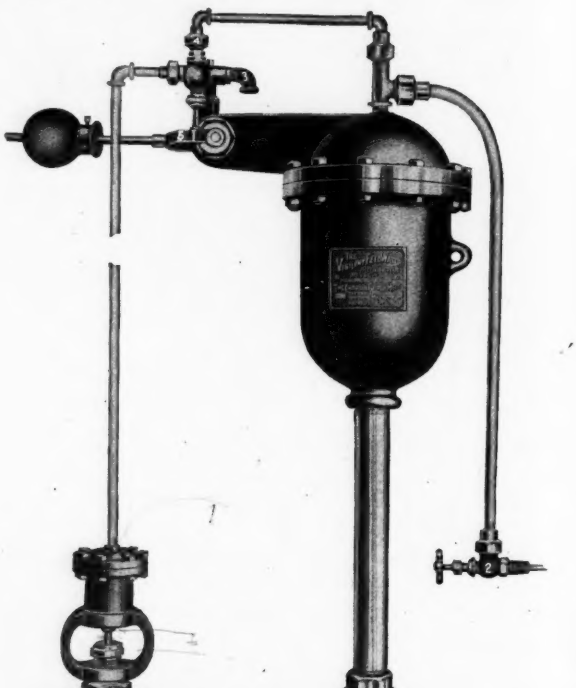


FIG. 6. VIGILANT FEED WATER REGULATOR

When the water level rises above the middle gage cock, the nipple, 2, is sealed by the rising water, and steam is prevented from entering the chamber. Condensation of steam already present will slightly reduce the pressure therein, so that water from the boiler completely fills the chamber. The displacement body now weighs less than it did, by the weight of the displaced water, and as it is now overbalanced by the counterweight, the lever falls, opening the steam connection and shutting the exhaust. Steam is then admitted to the piston chamber of the controlling valve, 6, and the feed water flow is shut off. Variation with this appliance does not exceed ½ in. from the desired level.

ELLIOTT FEED WATER REGULATOR

THE FEED WATER regulator made by The Elliott Co., of Pittsburgh, and shown in Fig. 7, consists of the regu-

lation water column containing a float with stem extending through the guide plate and engaging a lever which actuates a double-seated pilot valve. To this valve is connected an exhaust outlet and a line leading to the feed water regulating valve.

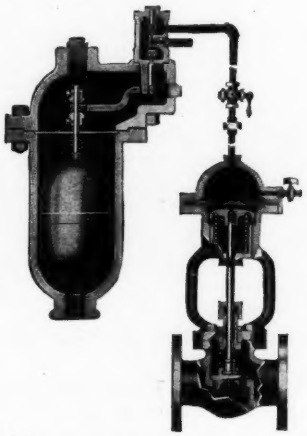


FIG. 7. SECTIONAL VIEW OF THE ELLIOTT REGULATOR

When the water in the boiler is at its normal level, the lower or admission end of the pilot valve is open, while the upper or exhaust end is closed, allowing the steam to pass through the pipe leading to the regulating valve and exert its pressure against the regulating valve diaphragm, thus cutting off the feed water supply. As the water in the boiler evaporates, the water level in the boiler and the column lowers, and the weight of the float is gradually transferred to the lever, overcoming the steam pressure and causing the exhaust end of the pilot valve to open. The weight of the float then closes the admission end of the valve, and the steam contained in the connecting pipe to the regulator valve passes through the exhaust end of the valve, and by way of the outlet pipe into the atmosphere, relieving the pressure on top of the diaphragm and permitting the regulating valve to open and admit water to the boiler. This continues until the water level has been raised about 2 in., and as it rises in the boiler and the column, the float has a tendency to rise likewise; but the steam pressure on the admission valve tends to keep it closed, consequently prevents the float from rising until the weight due to the increased displacement of the float overcomes the pressure at the admission valve, and as it opens, the exhaust valve closes, causing the steam to enter the regulating valve pipe, forcing the controlling valve to its seat, thus shutting off the feed supply.

The Watch Dog Feed Water Regulator

A PILOT VALVE actuated by a ball float independent of the water column is the operating principle of this regulator. As the float rises and falls with the water level in the float chamber, the pilot valve acts accordingly, increasing or decreasing the pressure on top of a valve diaphragm and thus closing or opening the controlling valve in the feed water line. Pressure of the feed water acting upon the under side of the valve diaphragm is more or less counterbalanced by a pressure produced on top of the diaphragm. This latter pressure is obtained by bypassing a small amount of the feed water around the controlling valve, as shown in Fig. 8, and discharging it into the boiler through the pilot valve in the regulator chamber, the bypass being connected to the top of the diaphragm.

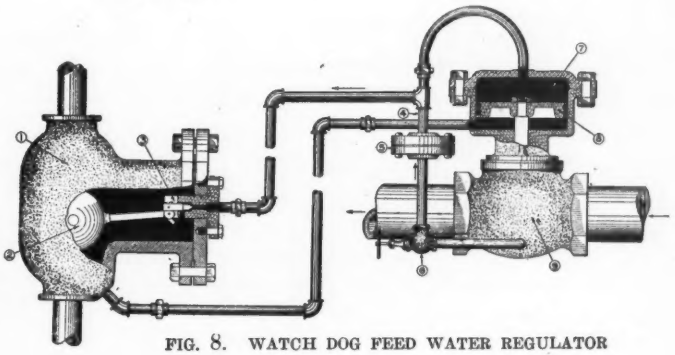


FIG. 8. WATCH DOG FEED WATER REGULATOR

Except under extreme conditions, the control valve does not entirely close or open and thus water is fed continuously by this regulator, which is made by the L. J. Wing Mfg. Co., of New York City.

The Thermofeed Regulator

ON THIS REGULATOR, which is made by the American Steam Gauge & Valve Mfg. Co., of Boston, Mass., it is possible to alter the working level while under steam

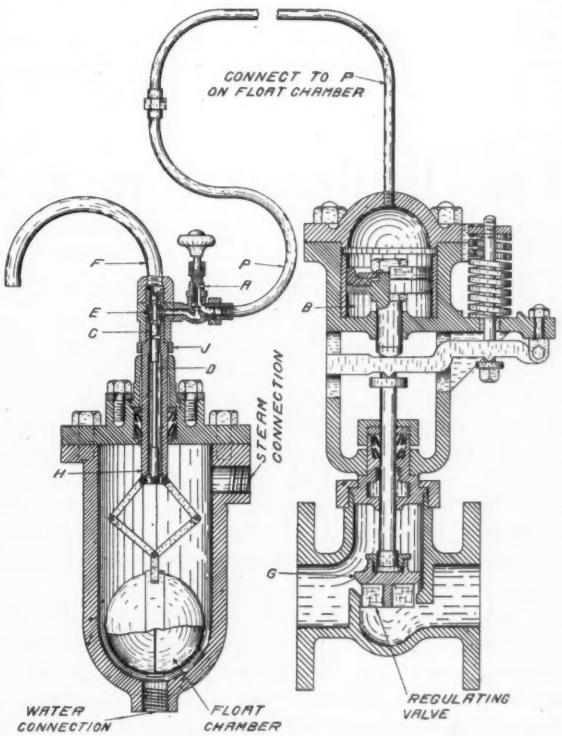


FIG. 9. THERMOFEED FLOAT CHAMBER AND REGULATING VALVE

and in operation. This adjustment is accomplished by turning the nut on the vertical spindle of the control valve, C, shown in Fig. 9, thus raising or lowering the

valve to the desired position. Placed in the pipe, P, which connects the float chamber and regulating valve, is a 3-way valve, A, which plays an important part in the regulator action; when at its outer seat, cylinder B of the regulating valve is placed in connection with the

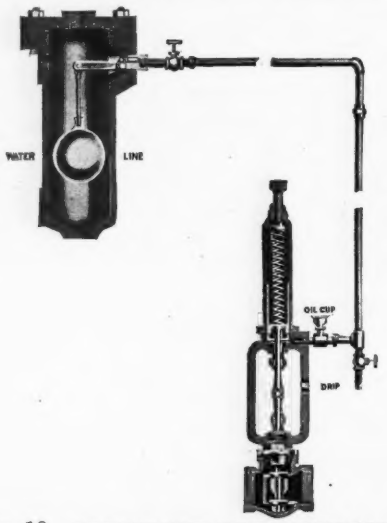


FIG. 10. MURRAY FEED WATER REGULATOR

control valve, C, and the Thermofeed is in commission; when A is on its inner seat, cylinder B is open to atmosphere, thus putting the Thermofeed out of action and leaving the regulating valve full open.

Attached by the rod, D, to the float through toggle levers, the double-seated controlling valve, C, performs the main function of the apparatus. Any movement of the float is diminished by a 10 to 1 ratio, then transmitted in a reverse direction through the toggles and rod D to valve C. If the water level and the float fall, valve C is raised to its lower seat, preventing any exit of steam through this, and simultaneously putting the lower face of cylinder B in direct connection to the atmosphere by way of ports in E and exhaust pipe F, and the main regulating valve G is opened. If the water level and the float rise, valve C is pulled downward on its upper seat, thereby permitting the passage of steam through the lower valve to the piston in cylinder B, in this way gradually depressing the regulating valve, G, to its seat.

All of the controlling mechanism in the float chamber is attached to sleeve H, and can be raised or lowered by turning the nut J. Variation of the water level is claimed not to exceed ⅛ in. for fire-tube and ¼ in. for water-tube boilers.

MURRAY FEED WATER REGULATOR

IN THIS REGULATOR, the water column is arranged as shown in Fig. 10 so that the rise and fall of a float controls a needle valve which, upon the fall of the water level, admits steam through the small pipe into the lower end of the cylinder, forcing up the piston against the tension of the spring and by means of a piston rod opens the regulating valve. This action admits water through the feed pipe into the boiler until the normal level is restored, when the needle valve will close by the rising of a float, shutting off the steam from the ¼-in. pipe and allowing the spring to close the piston, thus closing the regulating valve. The Murray regulator is made by the Murray Manufacturing Co., of Detroit, Mich. (To be Continued.)

The Unaflow Engine in Steel Works Power Plant*

COMPARISON WITH THE DUOFLOW ENGINE AND TURBINE. BY W. TRINKS

UNAFLOW engine history begins in 1907, when Prof. J. Stumpf, of Charlottenburg, Germany, began his designs and applied for patents. The characteristic part of the Stumpf engine, as is well known, is the cylinder with steam admission at the ends, discharge in the center, and steam jacketed heads (see Fig. 1.) The idea of steam admission at the ends in combination with central discharge is old and was patented to Todd in England in 1885, but the fact that the idea remained wholly unused until Stumpf proved that it was useful, when coupled with jacketed heads and a partly jacketed barrel, stamps Stumpf the inventor of the Unaflow engine from the viewpoint of the critical historian.

In 1907 Prof. Stumpf clearly recognized the thermal advantages to be gained from the unidirectional flow of steam through the cylinder. From 1907 to 1911 the evolution of that type of engine was virtually limited to Austria and Germany. In 1911 Prof. Stumpf published his book on the Unaflow engine, and bitter literary controversy on the merits or demerits of the Stumpf engine followed. In the same year American engineers began to take notice of the Stumpf engine and, one by one, the C. & G. Cooper Co., the Nordberg Manufacturing Co., the Mesta Machine Co., the Skinner Engine Co., and the Ames Iron Works took up the building of this type. A great deal had to be learned by these firms and some of the experience was quite dearly paid for. At the present date, the period of experimenting is virtually over, and the time is ripe for a review of the situation.

Principal claims made for the Unaflow engine are economy, simplicity, reliability and freedom from attendance.

In the steel works power plant this engine will have to compete with the gas engine and with the steam turbine. The gas engine uses 7500 to 9500 B.t.u. per indicated horsepower-hour, whereas the Unaflow engine, running condensing, uses from 11,000 to 13,500 B.t.u. in the steam, and more in the fuel gas, depending upon the boiler efficiency. There is, in consequence, little hope of replacing the gas engine by the Unaflow engine.

When we come to a comparison between the engine and the turbine, variation of steam pressure and of back pressure make it advisable to leave the B.t.u. basis and to introduce Rankine cycle efficiency, which means the

*From a paper read before the Association of Iron and Steel Electrical Engineers.

ratio of the work actually produced from unit weight of steam to the work which could be produced by the same weight of steam passing through the Rankine cycle. From a great number of published tests made on the very best turbines, the following averages for condensing operation have been obtained:

Size of turbine, kw.	500	1000	2000	5000	10,000
Rankine cycle efficiency (Referred to Brake hp.)	.62	.66	.71	.77	.82

For noncondensing operation the values are much lower.

For the Stumpf engine, data furnished by the Stumpf Unaflow Engine Co., tests made by the author and data from Ames Iron Works and from the C. & G. Cooper Co. indicate the following efficiencies:

Size of engine, kw.	300	600
From 3 lb. per sq. in. back pressure above atmosphere down to about 23 in. vacuum.	Efficiency.	
Saturated	71	74
100 deg. Superheat	75	77
200 deg. Superheat	78	79
For high vacuum (about 27½ in.)		
Saturated	58	62
100 deg. Superheat	62	65
200 deg. Superheat	66	68

Values may vary somewhat to one side or the other, but the general tendency is apparent. For non-condensing operation, for 100 deg. superheat, for moderate vacuum, and for sizes up to 1000 kw., the Unaflow engine is more economical than the turbine. It will, therefore, find a place in comparatively small power plants and in such locations where 28 in. of vacuum or better is not attainable. It will also be preferred for generating direct-current, because turbines for the generation of direct-current, when direct connected, are too slow for best economy. If they are to operate at economical speed, gears must be introduced.

Evidently, the Unaflow engine will have a limited field in the steel works power plant. Turning to the second application which interests us, namely, the driving of rolling mills, we find a changed condition. Let us here, for the sake of clearing up doubts, compare the Unaflow engine with electric drive and with the older type of duoflow engine. In comparison with electric drive, the steam engine does away with the electric generator, the switchboard, the transmission line and the motor, but it takes undesirable piping into the mill. The elimination of the electrical part means that we must compare the Rankine cycle efficiency of the engine to the Rankine cycle efficiency of the turbine, including generator, transmission line and motor. Allowing the high efficiencies of 92 per cent for the generator, 98 per cent for transmission line and 92 per cent for the motor, we must multiply the turbine efficiencies by 0.83 for comparison with the direct-connected engine. This procedure furnishes:

Size of turbine, kw.	500	1000	2000	5000	10,000
Rankine cycle efficiency					
referred to motor shaft	50	54	59	64	68
referred to mill shaft	47	50	55	60	64

The lower row of figures was obtained by multiplying the upper row by 0.965 by 0.965, this figure taking care of the efficiency of two speed reductions from the motor to the mill. A study of the resulting values shows that the Unaflow engine is ahead of the electric drive, unless the steel plant is so large that turbo units of over 8000 kw. capacity can be installed.

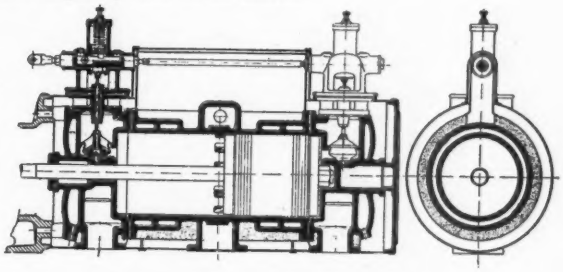


FIG. 1. CYLINDER OF STUMPF ENGINE

The economy of the Unaflow engine compared to that of the steam-turbine-electric drive, taken by itself, is not enough better to explain why the Unaflow engine should fare differently from the compound engine. The Rankine cycle efficiency of a good compound engine is virtually the same as that of the Unaflow engine, but there is one vital difference: To obtain that high efficiency, the compound engine must have a small high-pressure cylinder (which cuts down condensation area); but the small size of the high-pressure cylinder means a small overload

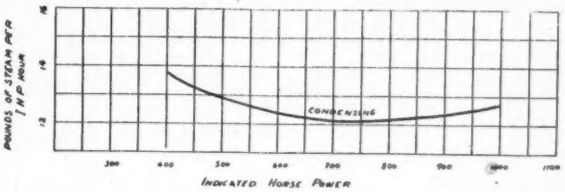


Fig. 2

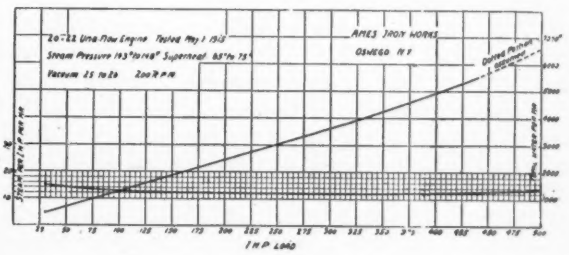


Fig. 3

FIG. 2. WATER RATE CURVE FOR COMPOUND ENGINE
FIG. 3. WATER RATE CURVE FOR UNAFLOW ENGINE

capacity, and quick departure from best efficiency for comparatively small changes of load. Figure 2 illustrates the water-rate-against-load curve for a well known compound engine. Comparison of this curve to the typical water rate curve of a Unaflow engine, Fig. 3 (Ames Iron Works), shows the difference to be very marked. Mill loads are notoriously variable, because small variations in draft, temperature of steel, velocity of rolling, etc., cause disproportionately great changes in resistance. It is not possible to foretell exactly what the load will be and it is therefore of the utmost import-

ance to secure a drive which permits over or underloading without serious change of economy. The Unaflow engine, and the electric motor, hitched to a large central station, both fill this requirement. The compound steam engine does not.

Variation in back pressure naturally affects the operation of the Unaflow engine. However, the vacuum may (with 4 per cent clearance) vary from 19 to 27 in. of mercury without unduly high compression, or pounding (due to lack of compression). If the vacuum fails altogether, clearance is automatically added, to keep the compression down.

It would be very interesting at the present time to compare, from actual installations, the cost of a Unaflow engine drive with that of an electric drive. Unfortunately, there are as yet too few installations of mill Unaflow engines in the United States to make such a comparison. However, the author knows from personal experience that a Unaflow engine with d.c. generator costs less than a geared steam turbine with generator. From that it may be concluded that an engine without

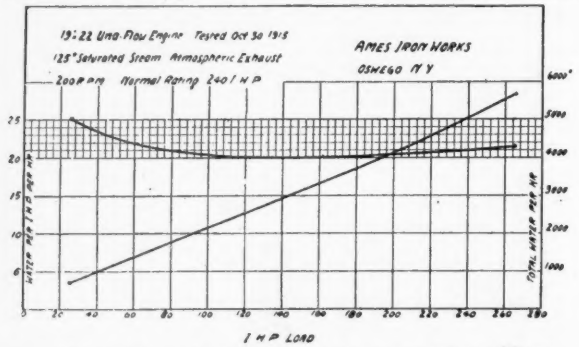

19:22 Una-Flow Engine Tested Oct 30 1915
125" Saturated Steam Atmospheric Exhaust
200 R.P.M. Normal Rating 240 I.H.P.
AMES IRON WORKS
OSWEGO N.Y.
I.H.P. LOAD

FIG. 4. STEAM CONSUMPTION CHART FOR 19 BY 22-IN. UNAFLOW ENGINE

generator, direct connected to the mill, will cost not less than a turbine plus generator, plus switchboard, plus motor, plus gear drive.

The secret of the economy of the Unaflow engine lies principally in reduction of internal cylinder condensation. In the duoflow single expansion engine, cylinder condensation is so great, that a very great free expansion loss must be allowed for best economy (or rather for minimum wastefulness). In the compound and triple expansion engine, cylinder condensation is reduced so that the free expansion loss can also be reduced, but mechanical losses due to the passing of the steam through so many valves become great. In the duoflow engine, cylinder head, cylinder barrel and piston head are alternately heated and cooled by live steam and exhaust steam sweeping over them and wiping heat "on and off." In the Unaflow engine, only the piston head has heat wiped off during the extremely short period of exhaust, the steam near the place of entrance of live steam being at rest like the fixed end of an expanding coiled spring during exhaust, and like that of a compression spring during compression. Besides, the cylinder head and part of the barrel are steam jacketed, and steam jacketed surfaces are cooled very little by stagnant steam. It may be remarked again that the mere provision of a central exhaust does not bring about a successful Unaflow engine; the steam jacketing of the heads and of part of the barrel must go with it to produce thermodynamic superiority over the duoflow engine.

In the duoflow engine, long compression means increased steam consumption, principally, because the steam temperature exceeds the cylinder (or piston) wall temperature a longer time than it would with shorter compression. In the Stumpf Unaflow engine the steam which is being compressed is in contact with progressively hotter surfaces, with the exception of that of the piston, and the steam temperature never rises very much above the wall temperature. Enforced or compulsory tightness is the second reason for the economy of the Unaflow engine. Steam cannot leak from the live steam space to the exhaust. If the inlet valves are leaky to any extent, the compression rises so quickly that the inlet valves clatter and give notice to the engineer that something is wrong.

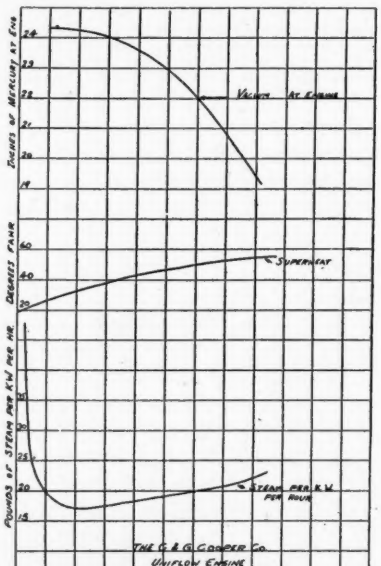


FIG. 5. STEAM CONSUMPTION CHART OBTAINED FROM TEST

Development of the Unaflow Engine in the United States has been slow, probably because it did not fit into the general trend of changing from reciprocating to rotating machinery, and because it is of foreign origin. It began in a small way in 1912. Experiment showed that the Corliss releasing gear, in its usual form, is not ideal for the Unaflow engine, because the cutoff is so short, because modern plants carry high pressure with superheat, and because the pressure drops so fast after cutoff that the valve becomes unbalanced too quickly for the ordinary design and size of vacuum pot. In consequence, the Mesta Machine Co. and the Nordberg Co. are using poppet valve gears, while the Cooper Co. has adapted the Corliss gear and vacuum pot to the new conditions. The Mesta Machine Co. makes its poppet valve gear non-releasing, while the Nordberg Company uses a releasing gear. The latter type of gear does not find favor with German engineers on Unaflow engines; they claim that it is not adapted to the short cutoff required.

Unaflow engines of the smaller size have been developed by the Ames Iron Works, of Oswego, N. Y., and by the Skinner Engine Co., of Erie, Pa. The Ames Iron Works, from the very beginning, adopted poppet valve steam distribution, with shaft governor drive. This design is well adapted for small engines up to 400 or 500 hp. For larger sizes and high steam temperature it is not so well adapted, because the difference in expansion between the valve rod and the cylinder becomes too great and disturbs steam distribution. For poppet valve engines above 500 hp. the lay shaft drive is preferable.

In the sizes built by the Ames Iron Works, a self supporting piston, guided at the crank end only, is perfectly satisfactory. In larger sizes this same design leads to a great deal of trouble. On account of difference in expansion, the piston must be a loose fit in the cylinder, and the guiding of the piston by the crosshead is imperfect. The piston, therefore, wobbles around in the cylinder, riding now on one spot, then on another, never wearing itself in, but rapidly wearing itself out. In large engines of German design, a tail rod guide has been provided, not so much for the purpose of carrying the piston, but mainly for the purpose of guiding it, so that it will always touch the cylinder in a large surface. American engineers have gone one step further and have made the piston-rod strong enough to carry the piston.

Progress of the American Boiler Code

FOLLOWING the work of the American Uniform Boiler Code Congress at Washington, much correspondence has been carried on with various states by Thomas E. Durban, Chairman of the Uniform Boiler Law Society, and it is now certain that bills will be introduced in Texas, Michigan, Minnesota, Kentucky, Illinois, Missouri, Connecticut, Rhode Island, New Jersey, Virginia and Tennessee, at the next meeting of the Legislatures. All engineers interested in the advancement of boiler practice should take up the matter with their representatives and use their influence to see that the bills are passed when they come up for action.

In all cases, the effort is to have an Enabling Act passed, instructing some department already existing in the state, to draw proper rules governing the construction and installation of boilers. It has been found impractical to put technical legislation on the Statute Books, particularly where the rules are of necessity to be revised as practice changes, but an Enabling Act permits the Code to be adopted by some department of the state, and also gives the department power to change these rules, from time to time, as may be found desirable.

The Industrial Commission of Ohio has already announced that the Code will be in effect in that state after April 1, 1917, for all new construction, and in the other states mentioned, prominent men are actively interested in the preparation and introduction of Enabling Bills. In the various states, the men in charge are as follows: For Texas, Hon. C. W. Woodman, Commissioner of Labor; for Michigan, J. C. McCabe, Boiler Inspector for Detroit, and J. G. Hoffman, Secretary of the Manufacturers' Association; for Minnesota, Senator Denegre, Oliver Crosby of the American Hoist & Derrick Co., and Max Toltz; for Kentucky, Prof. F. Paul Anderson, Dean of the University; for Illinois, B. F. Baker, Treasurer of the Kewanee Boiler Co., and Owsley Brown of the Springfield Boiler & Engine Co.; for Tennessee, Hon. W. L. Mitchell, Commissioner of Labor; for Connecticut, Prof. L. P. Breckenridge, of Yale University, and S. F. Jeter; for Rhode Island, Prof. W. M. Kenerson, and the Providence Branch of the National Metal Trades Association; for New Jersey, Gen. Lewis T. Bryant and Jos. F. Scott; for Virginia, Prof. L. S. Randolph. Geo. A. Luck, Chief Boiler Inspector for the State of Massachusetts, voted in favor of the resolutions, and will give his assistance to having the Code recognized in that state.

The success of the Code is now thoroughly assured in most prominent states of the Union; but it needs active, personal work of every interested man to insure that the Enabling Acts shall be passed at the next sessions of the various Legislatures. A condensed report of the meeting of the Uniform Boiler Code Congress has been prepared, and this will be sent to selected names to enable all people interested in such legislation to know what is sought, and the advantages in protection of human life and in increase of the efficiency of power plant practice. These reports can be secured by writing to Thomas E. Durban, Erie City Boiler Works, Erie, Pa.

Flywheel on Rolling Mill Engine Lets Go

By E. C. Smith

AT about 1:00 a. m. Friday, Dec. 22, 1916, the 14-ft. flywheel on the large engine which drives the rolls for the Harrow Spring Co. on E. Vine St., Kalamazoo, Mich., exploded, killing one man instantly and seriously injuring 2 other workmen; 3 others were slightly injured. This engine has been in rolling mill service for about 12 yr. and has stood up well under the great strain to which it was subjected, its minimum, or friction load was about 140 hp. and the maximum, or peak load about 1000 hp., and the change from low peak to high peak would take place within 30 sec. often, and the writer has seen the load dropped almost instantly.

This was a Porter Allen engine, 4-valve type, link valve motion, Porter Allen governor, and the governor has always worked perfectly, and after the accident, the governor was examined and found intact, with the belt in its proper position, and all parts about the governor normal. The engine was 22½-in. bore and 36-in. stroke, the broken wheel had a 38-in. face, the rim was about 2½ in. thick, was turning 143 r.p.m.

The hub of the wheel was intact, and showed no movement whatever on the shaft or key. One thing that the writer noticed in particular was the manner in which the spokes had parted from the hub; instead of short stubs of the spoke being attached to the hub as is often the case, the spokes were all broken off flush, or a little below the surface of the hub.

The coroners attached no blame to anyone for the accident.

Electrical Machinery and Appliances

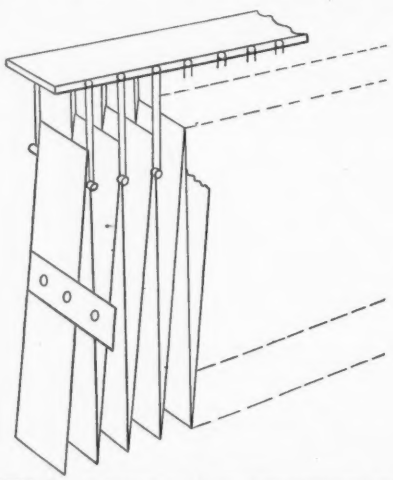
For Generating, Transmitting and Using Current

An Inexpensive Resistance

USE OF EASILY-CONSTRUCTED LOW-CARBON STEEL GRIDS RESULTS IN SATISFACTORY SERVICE AND REDUCED COSTS. BY EUSTIS H. THOMPSON

LOW-CARBON steel, with its relatively low electrical resistance is seldom considered for constructing grids; yet in the following instance, attendant circumstances made it possible to effect a large saving by using such material instead of cast iron.

A turbine with 2 direct-connected generators was installed in a large steel plant, where it was sometimes necessary to run in multiple with a plant 1500 ft. away containing 2 engine generators. On account of compounding and load conditions, it was found necessary to connect the two plants by an equalizer. The turbo gen-



METHOD OF ARRANGING AND SUSPENDING GRIDS

erators had low-resistance series fields, while the engine generators had high-resistance fields, which, together with the line loss, required a resistance to be placed between the series field and equalizer bus bar in each turbo generator that would give 10-v. drop with a normal load of 1500 amp. These grids were to be short-circuited when multiple operation was not necessary.

In considering the cost of these unusually large grids, it was found that the standard factory-made resistances would cost about $600. In order to reduce this cost, the possibility of utilizing rolled steel as turned out by the mill was investigated. The steel grids were then built for $70, or about 1/9 the cost of the standard grids.

There were several reasons why a saving was effected by using steel. The standard-type resistances were made up of a large number of small grids, bolted together, which required much drilling and machining of joints. The steel resistances were each made in one continuous piece with a few welded joints, with holes punched at regular intervals for bolting connector. Standard resistances required slate bases and copper connectors while the steel resistances were suspended from the ceiling, and required connectors, which were of steel, only where the main cables were bolted on. Also, the steel was purchased and prepared at moderate cost, so that the retail prices would probably have been 50 or 100 per cent greater.

A sample of the steel used was tested under continuous load to get an idea of resistance and radiation losses. The grids were then figured with the idea of producing a 10-v. drop at 1500 amp. with a normal temperature rise of 60 deg. C. (140 deg. F.) above the room temperature. The 10-v. drop included cables and connections, so that the net drop in the steel grid was 9.5 v. Ample allowance was made for adjustment, in case more or less resistance should be preferred. After the grids were put in service, it was found that the total drop between generators and board was exactly 10 v., and the rise in temperature was 63 deg. C. (145 deg. F.) above the room. This was accomplished on the first adjustment of the grids.

Each grid consisted of a steel strip 1/8 by 12 in. by 150 ft., folded up in a zigzag of 5-ft. lengths. Two 5/8-in. holes for bolting cable connector were punched in the sections used for bolting. The grids were suspended and insulated, as shown in accompanying figure. The amount used at the first trial, which proved to be correct for operating, was 23 sections, or 115 ft. in each grid.

The constants for these grids were found to be: rise in temperature, 63 deg. C. above room; resistance of used portion $\frac{9.5 \text{ volts}}{1500 \text{ amp.}} = 0.006{,}33$ ohms. Resistance per square inch per foot is $\frac{0.006{,}33 \times 12 \times 0.125}{115} = 0.000{,}082{,}5$ ohms.

Radiation constant is:

$$\frac{\text{Total watts}}{\text{Total area}} = \frac{9.5 \times 1500}{12 \times 115 \times 12 \times 2 + 0.125 \times 115 \times 12 \times 2}$$

= 0.425 watts per sq. in.

The loss of energy would appear impressive if figured in pounds of coal per year, but as the turbine used exhaust steam, and a large amount was usually to spare, the 3 or 4 per cent more or less, had no appreciable effect on the actual coal consumption. Besides, the importance of this power and its low cost of installation, in comparison with another location, where such large grids would not have been needed, would have been more than an offset.

Steel Conductors for Transmission Lines*

SOME CHARACTERISTICS AND COSTS OF INSTALLATION. BY H. B. DWIGHT

ALTHOUGH results of a number of tests of the electrical properties of steel wires and cables when used as conductors of alternating current, have been published, these tests are incomplete, especially as regards the use of steel conductors in America, but they show some attractive possibilities for the use of steel instead of copper in certain classes of work. Already, small sizes of steel conductors have been used with success in America, and this practice may be extended by a knowledge of the characteristics of large steel cables.

As is well known, the resistance of an iron or steel conductor is considerably greater for alternating current than for direct current. This is partly due to the skin effect, that is, the crowding of the alternating current to the outside parts of the conductor by the alternating magnetic flux in the conductor, and partly to hysteresis, or iron loss, caused by the alternating magnetic flux in the steel. In the case of copper or aluminum transmission-line conductors of usual size, the skin effect increases the effective resistance only 1 or 2 per cent and so is virtually negligible. But in the case of iron or steel conductors, the flux has a magnetic path, and so attains a value from 20 to several hundred times as great as in a non-magnetic conductor. The result is that the skin effect is very pronounced and the effective resistance is increased by a large amount, in some cases by 100 or 200 per cent or more.

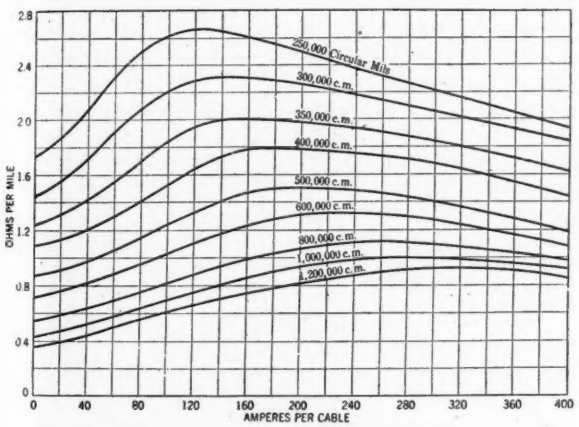


FIG. 1. RESISTANCE CURVES FOR 60-CYCLE 49-WIRE STEEL CABLES

The tests so far published go to show that it is as necessary for an iron a.c. conductor to have fine strands as for an iron core to have thin laminations. The tests also indicate that if the strands are moderately fine and are properly put together, the increase of resistance at 25 or 60 cycles may be kept down to a reasonably small percentage. This is shown in Figs. 1 and 2, which refer for the most part to a grade of steel or iron called H-oo, a medium grade recommended for alternating-current work. Although the purer material has higher conductivity for direct current, it has also greater permeability to magnetism, which is a disadvantage. Thus the cheaper grade was found to be more suitable for a.c. work.

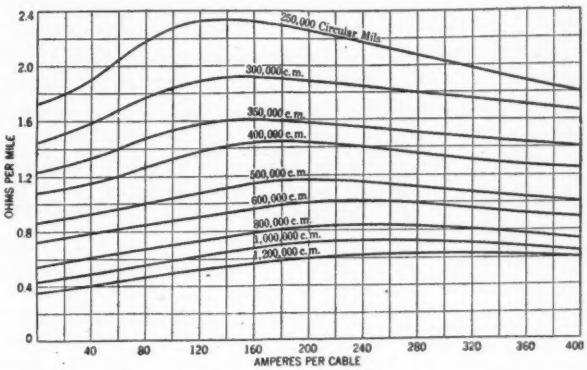


FIG. 2. RESISTANCE CURVES FOR 25-CYCLE 49-WIRE STEEL CABLES

The tests on grade H-oo steel, which were originally expressed in centimeter units and were made at 50 cycles, have been rearranged for English units and for 60 and 25 cycles, and put on a base of amperes per cable. The Bureau of Standards' tests show that at commercial frequencies the increase of resistance is approximately proportional to the frequency, and this property was made use of in making the above transformations.

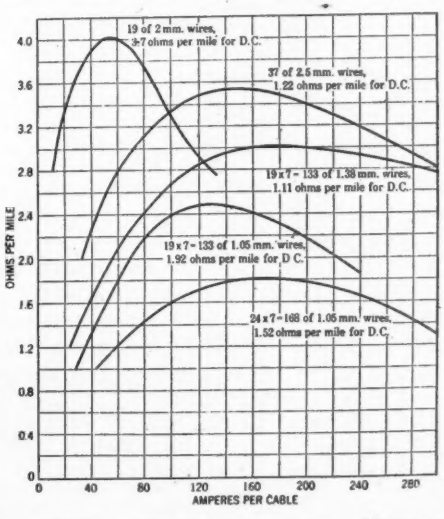

OHMS PER MILE
AMPERES PER CABLE
19 of 2 mm. wires, 3.7 ohms per mile for D.C.
37 of 2.5 mm. wires, 1.22 ohms per mile for D.C.
19 x 7 = 133 of 1.38 mm. wires, 1.11 ohms per mile for D.C.
19 x 7 = 133 of 1.05 mm. wires, 1.92 ohms per mile for D.C.
24 x 7 = 168 of 1.05 mm. wires, 1.52 ohms per mile for D.C.

FIG. 3. INTERNAL REACTANCE CURVES. 60-CYCLE GRADE S. S. W. STEEL

Shown in Fig. 3 are the curves of internal reactance of steel cables. These curves do not refer to grade H-oo steel, but to a grade of higher permeability. The

*From a paper read before the Association of Iron and Steel Electrical Engineers.

tests show that the resistance curve and the reactance curve of a given cable reach their maxima at about the same value of current. It is of interest to note that increasing the number of wires in a cable decreases the reactance, while increasing the size of the wires increases the reactance.

The d.c. resistance of each cable is given in Fig. 3, and the maximum a.c. resistance will be about twice as great, according to Figs. 1 and 2. From the results shown in Fig. 3 the internal reactance at 60 cycles and at any current may be taken as being about 75 per cent of the a.c. resistance at the same current, in the absence of more complete data. The external reactance should be taken from regular transmission-line tables and added to the internal reactance to give the total reactance. This is the method by which the example at the end of this article has been worked. It is merely approximate, and the caution should be given that for practical designing, test curves of the resistance and reactance of the actual type of cable to be used should be employed.

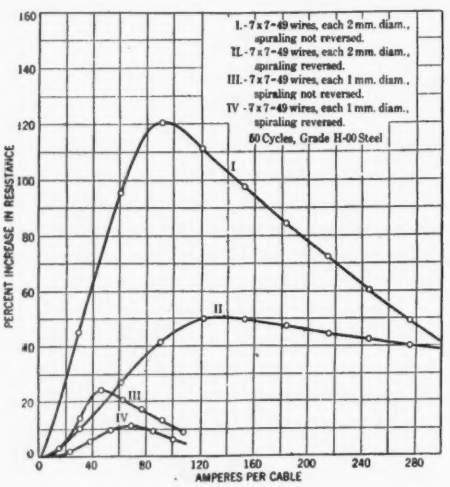


FIG. 4. EFFECT OF SPIRALING

Much of the magnetization is caused by the spiraling of the wires in a cable, and if the spiraling of the different groups of wires is properly reversed, the increase in effective resistance can be reduced as much as one-half. Actual examples of this are shown in Fig. 4. Thus if the spiraling of one layer of wires is clockwise, the spiraling of the next layer should be counter-clockwise. Also, in a cable made up of several strands, the spiraling of the wires in each strand should be opposite to the spiraling of the strands in the cable. In Figs. 1 and 2, the cables are assumed to have the spiraling reversed as much as possible. Since spiraling produces so strong an effect, the pitch of the spiral should be as long as possible without endangering the strength of the cable.

The curves show that iron and steel conductors have the peculiar property that the effective resistance and reactance increase to a maximum as the current is increased, and then decrease. This property should prove useful in transmission-line work, for the conductor will have a low impedance to the normal load current, but will have about twice as much impedance to the current flowing in case of a short circuit. The impedance will also be large to high-frequency surges caused by switching or lightning. It may prove more economical in certain cases to protect a line against short circuits and surges by using steel conductors than by installing current-limiting reactors or by increasing the reactance of the transformers.

This property may also be of use in the case of feeders of direct-current interurban railways. If the feeder be a steel cable it will have low resistance to direct current, but high impedance to alternating currents. It will, therefore, tend to damp out the suddenness of short circuits, and lightning surges, which cause synchronous converters and generators to flash over. That there is need of taking precautions against flashovers in this way is shown by the fact that it has already become the practice to make the nearest connection between a feeder and the trolley wire several thousand feet from a synchronous converter or generator so that the latter will be protected by the resistance of a long stretch of feeder in case of surges or short circuits. If the feeder be made of steel, and especially if the stranding be coarse, the required protection will be still more complete. Steel conductors would probably be economical only where it is allowable to use bare cables, for the large size of steel cables compared with copper ones would greatly increase the cost of the insulating covering.

Higher conductivity of steel for direct current than for alternating current makes the use of bare steel cables for d.c. feeders more economical than for a.c. lines. A steel cable has about 8 times as much resistance to direct current as a copper cable of the same size, and therefore 7 times as much resistance as a copper cable of the same weight, since copper is more dense than steel. But galvanized steel cables usually cost less than 1/7 as much as copper cables per pound, and so should be more economical, other things being equal.

Steel cables have frequently been used on transmission lines for long spans up to 3000 ft. or more. In some cases the steel cable has been the support for a copper conductor, but in many cases the steel cable itself has carried the electric current. Such applications are of such a short length compared with the entire transmission line that they have been chosen, not because of a comparison of the cost and conductivity of steel and copper, but because copper or aluminum would be too weak for such long spans, and a much stronger material, like steel, was absolutely necessary in order that the transmission line should be mechanically safe.

Another application of steel conductors which has already met with success is for small size conductors, as previously mentioned. Here again it has not been the relative conductivity, but the greater tensile strength, which has induced the choice of steel rather than copper. It is not the practice to use a smaller copper wire than No. 6 (0.162 in. or 4 mm. diameter) for overhead lines, because any smaller copper wire would be mechanically too weak. But it is often profitable to supply a small load at a distance of several miles, which would require only a fraction of the conductivity of a No. 6 copper wire, and in such cases a No. 8 or larger steel conductor has been found to have sufficient conductivity and mechanical strength, and to cost much less than No. 6 copper.

According to a description recently published, a large 60-cycle power system in the State of Washington makes use of a considerable quantity of No. 8 iron wire for short tap-offs and lightly loaded branch lines on 6600-v. circuits, without serious trouble resulting from voltage drop. This iron wire is of course far cheaper than No. 6 copper. One line built by the above company is an example showing that it may be profitable to supply a surprisingly small load at a distance of several miles. This line is 10 miles long and was originally built with No. 8 copper clad steel to supply a 50-hp. motor load at 6600 v. The line afterward carried 110 hp. for some time and was later changed to No. 6 copper in order to have a capacity for a still greater load.

An example from Minnesota shows the use of a somewhat larger steel conductor. This line operates at 40,000 v., 60 cycles, and is 20 mi. long. No. 4 galvanized steel cable, made of 3 wires, is used. The load is about 300 kv.a.

EXAMPLE I

Length of line	7 miles
Voltage at receiver	11,000 volts
Frequency	60 cycles
Power factor of load	85 per cent
Phases	3
A. Conductor	7-wire steel cable
Size	25,000 cir. mils
Diameter of cable	0.18 in.
Diameter of wires	0.06 in.
Resistance per mile at full load	17.6 ohms
Full load	75 kv.a.
Voltage drop at full load	9.6 per cent
Weight of conductors	7300 lb.
Cost of steel cables at 3 cents per lb	$220
B. Conductor	Single steel wire
Size	25,000 cir. mils
Diameter	0.158 in.
Resistance per mile at full load	23 ohms
Full load	75 kv.a.
Voltage drop at full load	12.5 per cent
Weight of conductors	7300 lb.
Cost of steel wires at 3 cents per lb	$220
C. Conductor	Single copper wire
Size	No. 6, 26,250 cir. mils
Diameter	0.162 in.
Resistance per mile	2.14 ohms
Full load	750 kv.a.
Voltage drop at full load	9.5 per cent

Described in Example I is a line with small conductors, where steel is cheaper to employ than the minimum size of copper. Here a 7-mile steel line can be designed for 75 kv.a., but the smallest copper line that can be designed would be rated at 750 kv.a. Thus, while the poles and insulators will be the same in both cases, the steel conductors will cost only $220 against a cost of $2600 for copper. It is this large difference in cost which has been the main reason for using steel conductors on the branch lines of the power systems previously mentioned. This difference in cost of course is greatest when the price of copper is highest.

Besides being cheaper than the copper cable for small branch lines, the steel cable has the advantage of being mechanically stronger and less liable to be burned through by arcs. The steel line has therefore greater reliability at times of wind and sleet storms and at times of electrical breakdown or trouble. Steel cables are subject to the disadvantage that their useful life is shorter than that of copper cables, especially near the seacoast, where galvanized steel is more quickly oxidized.

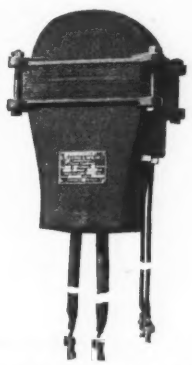
Example I shows also the advantage of using fine stranding. The 7-wire steel cable gives 9.6 per cent drop, while a solid steel wire of the same cross-section has 12.5 per cent drop at the given load, according to tests of grade H-oo steel.

Weight of conductors	8800 lb.
Cost of copper wires at 30 cents per lb	$2600

Safety Coils for Series Alternating Current Circuits

FOR USE where the voltage of series arc or incandescent alternating current circuits is too high to permit the safe installation of lamps, the safety coil illustrated herewith has been developed. These coils are for indoor and outdoor service and are especially useful on installations where a series lighting system is desirable but high voltage impracticable, or where but a few lamps are required and a multiple circuit is not available.

The coils are essentially one-to-one ratio series transformers insulated for high potential, being tested for 20,000 v. for one minute between windings and between



WESTINGHOUSE SAFETY COIL FOR SERIES ALTERNATING CURRENT CIRCUITS

windings and iron. The smaller capacities of these coils are built for air cooling. The magnetic circuit, having laminations exposed to the air, is clamped between cast-iron end caps which protect the windings, the leads extending downward through suitable bushings in the bottom end-cap. The coils are impregnated with an insulating compound which thoroughly seals the joints between laminations and end-caps. The larger capacities are oil insulated and are of the same form of construction as the oil-insulated distributing transformers made by the same company. When installed, the primary of the coil is connected in the regular series circuit, the secondary then supplying the lower potential series circuit. Regular series lighting fixtures should be used.

LETTERS DIRECT FROM THE PLANT

Cash Paid For Ideas Accepted. Sketches Desirable.
We Make The Drawings

Charging Automobile Batteries

REFERRING to the charging of automobile batteries as discussed on page 1041, Dec. 15 issue, I submit the following, which may be of service to other engineers.

It often occurs that some circuit is already carrying the same current required for charging a battery, a small decrease in voltage not being detrimental to the connected apparatus. The battery may be charged by connecting in series with this line, but with its voltage in opposition to the flow of current. No material loss of energy will be occasioned with this arrangement.

Again, a line may be available for this purpose, as described, but where the amperage is in excess of that desired for the battery, the charging current may be

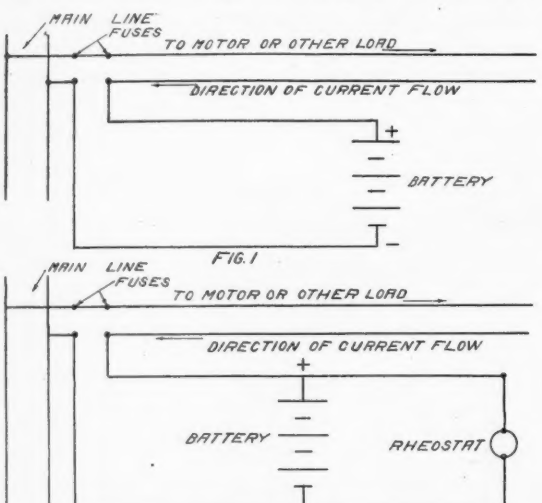


FIG. 1. WHERE CURRENT FLOW IS EQUAL TO THAT REQUIRED BY BATTERY THIS CONNECTION MAY BE EMPLOYED
FIG. 2. WITH AN EXCESSIVE CURRENT FLOW CONNECT BATTERY ACROSS AN ADJUSTABLE RHEOSTAT

obtained and regulated by placing a rheostat in parallel with the battery, Fig. 2. If this rheostat is not available wire may be used instead. It should be remembered that in both of the foregoing methods, while there is no material loss of energy, there will be a reduced voltage delivered to the receiving apparatus operating on the line. This will amount to about 5 per cent.

A small generator is often employed to supply lights in a factory where there is not much variation in the load. In this case, the battery may be connected as shown in either Figs. 1 or 2, as necessity requires, the voltage on the generator being raised an amount equal to the drop across the battery. J. M. Row.

Selecting Units for Power Plants

THE WRITER has read with considerable interest the article appearing under the above title, by J. C. Hawkins, on page 1034 of the Dec. 15, 1916, issue of Practical Engineer. I have not had time to analyze the article thoroughly, but from a practical point of view would make the following comments:

The load curve as illustrated is much better than any that will be found in practice for a similar situation. The average load factor for a plant of this size and character would not be over 15 or 20 per cent. The load factor of the curve as shown is roughly 55 per cent, term load factor as used being taken as the ratio of the average load over 24 hr. to the peak load.

It is not clear just why he uses the generator efficiency of 90 per cent in arriving at the generating capacity required. This feature concerns only the engine capacity.

In a properly designed plant with modern machinery, I do not believe that the over-all consumption would run more than 40 lb. of steam per kilowatt-hour in a condensing plant; certainly 50 lb. is too high.

With the conditions as outlined, I believe that the proper installation is 2 200-kw. generators with provisions for the increase in plant by making space for a third one at a future date. The difference in economy between the 200-kw. and the 125-kw. generators at the lighter load would hardly justify the installation of the smaller machines. If the small machine is installed, it will, of course, increase the cost of the plant, thereby increasing the fixed charges. It is a question of balancing the savings of the small machine at periods of light loads against the increased investment charges incurred by installing it, and under the conditions I do not believe that it would be justified.

Three 200-hp. boilers appear to be just about right for the plant conditions as two of them will carry the load allowing the third for cleaning and repairing. The boilers should be figured on the basis of 150 per cent of rating for conditions. This is on the assumption that horizontal return tubular boilers with hand-fired grates are used. If water-tube boilers and stokers are considered much higher overloads would be good practice.

It appears to me that the engine capacity should be somewhat larger for the generators as selected. For a 200-kw. generator, a 325-hp. engine should be used and for a 125-kw. generator, a 200-hp. engine. This will allow of better speed regulation and give some spare capacity in the engine which is very desirable.

The question as asked is, of course, more or less general and without further details it is impossible to work

out the solution in full. Any problem of this character is really a question of dollars and cents and practical operating consideration. While it may be worked out theoretically, it should be finally decided on the basis of good horse sense. R. A. LANGWORTHY.

Cylinder Lubrication

I READ with a great deal of interest the article in Dec. 15 issue of Practical Engineer on Lubrication of Steam Engine Cylinders, by John Rome Battle. I derived a great deal of solid useful information from the said article; however, in the paragraph on piston speed, he said: "If we figure the number of square feet of cylinder surface rubbed over by the piston in a given length of time and with the amount of oil fed during that time, it is possible to figure the number of pints of oil required per 100,000 square feet of rubbing surface."

If I did not know from frequent observation of cylinders, I should have been alarmed for fear I was not feeding enough oil to our 14 by 15-in. Harrisburg Fleming engine direct connected to Western Electric 100-kw. d.c. generator making 260 r.p.m.

When I took charge of this plant 3 yr. ago, the amount of oil used was excessive and I have been gradually reducing the amount until I now use only 1 qt. in 7 nights' run, averaging 6 hr. per night, which, in round numbers, is something like 2,999,264 sq. ft. of cylinder rubbed over per pint of oil used, and the surface of the cylinder is as smooth as glass, showing that the amount of oil used is ample. I also have an 8 by 12-in. Marsh vacuum pump which does perfect service on a consumption of 1 pt. to 1,375,152 sq. ft. of rubbed surface.

E. R. RIVERS.

Operating Condensing Engines

NOTING the correspondence on the subject of operating condensing engines in recent issues of Practical Engineer, and seeing no reference to the surface condenser, I am wondering why no mention was made of it. The surface condenser plays an important part in plants today, especially where cooling water is plentiful, or efficient spray cooling ponds are established. D. W. did not state anything about the type of condensing plant in regard to which he desired information, so it has been confined to the jet type. Good information is obtainable on various types in the Jan. 1, 1916, issue of Practical Engineer referred to by O. H. H.

I would say that if D. W. desires information on surface condensers the plan followed in my plant (which is fitted with both types of surface condensers) is to close the vacuum breaker and start the condenser. If it is a combined air and circulating pump type used for small engines, you have only to see that the proper suction and discharge valves are open on air and water ends and start up, the atmospheric exhaust line being closed by your vacuum breaker. A vacuum will be formed in your low-pressure receiver, or the exhaust line, if a simple type engine; when the desired vacuum is registered on your gage, you are ready to start the engine.

If the surface condenser is a large one, it is probably fitted with independent air and circulating pumps, in which case the circulating pump is started first, then your air pump, and when the vacuum is as desired start the engine.

When shutting down the engine, it is always best to allow the condenser to run at least 10 or more minutes longer. This will dry out the cylinders and receivers. When no more exhaust is entering the condenser from any source, and the condenser heads feel cool, it can then be shut down. The reason for such precaution is: If the condenser is shut down and is allowed to become hot at the head ends, the tube packing will tend to dry with possible resulting leakage. After both engine and condenser have been shut down, you may open the vacuum breaker at the atmosphere.

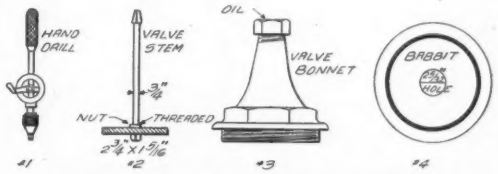
You need not be afraid of any damage resulting from stopping the engine with a surface condenser running, for the cooling water is separated from the exhaust steam. If you wish to run noncondensing, you must, of course, open your atmospheric exhaust and cut out the condenser exhaust. In some plants, other machinery exhausts into the condenser and in such a case the condenser must be kept running as long as any other such machinery is exhausting into it.

Engine drains may be piped to the condenser, and, of course, opened when starting or stopping, or when wet steam is getting into the cylinder. C. H. W.

Regrinding Valve Seats

RENEWABLE DISC, flat seated globe valves, subjected to hard use are used through the plant. The pile of valve bodies in the scrap pile with cut or scored seats reached such proportions, and the bills for valves came so often, that the superintendent began to "kick." The writer decided to reduce the bills, which was done in the following manner:

I secured old bonnets and stems from ¼ to 3 in., ground off the threads on stems, then shaped the ends so that they would fit the chuck of a hand drill or



TOOLS USED FOR REGRINDING VALVES

brace. Different size mill files were annealed by heating and allowing them to cool, cut off with hack saw to the required size, drilled and tapped to fit thread on end of stem and then rehardened by heating and plunged into cold water. The cutters are fastened as shown in the illustration; ¼-in. to and including 1¼-in. are practically self-centering. The 1½ to 3-in. I heated and filled with babbit, allowing both to cool and shrink together. This keeps the babbit from getting loose. Holes were then drilled for a neat working fit for the stem.

When it becomes necessary to renew a valve disc, the seat is examined and if any wear is noticed, the "grinder" is put on and the seat trued up.

The writer has experimented with several homemade devices, but has found the one here illustrated the most successful.

The sizes shown in the illustration are for a 2-in. valve. JACK L. BALL.

Packing High-Pressure Pumps and Accumulators

I HAVE NOTICED some discussion on the above subject in some of the late issues of Practical Engineer, and wish to state that on pumps of this type which I have handled and which carried pressures up to 2500 lb. per square inch, I have used only ordinary square braided flax packing well treated with graphite. If, however, the plunger is worn or the brass ring at each end of the stuffing box is out of round, no packing on earth, I believe, will hold longer than 18 to 24 hr.

After removing the plunger and having it turned and finished up until as smooth as can be, and refitting brass ring to rod and box, the packing will last for months.

Do not neglect the rod, and keep it well greased.

J. C. LEE.

The Cow's Natural Curve

A SMILE flitted over my boss's face as he read a recent contribution on "Which side of a belt should be run next to the pulley, hair or flesh?" I knew he was going to say something that he thought witty, and he did.

He said, "They'd have a dickens of a time fitting pulleys to some of the steers I have seen. This fellow in the paper here argues that the flesh side should be run

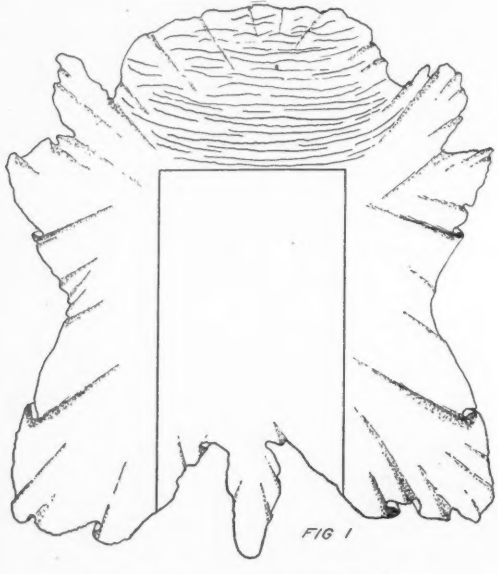


FIG. 1. PORTION OF HIDE USED FOR BELTING
FIG. 2. SECTION OF HIDE ON STEER'S BACK

next to the pulley because that's the way the hide was on the cow. He says it's the natural curve that should be fitted to the pulleys."

Here my boss pulled an old envelope out of his pocket and drew this little sketch, showing that the belt generally comes from the backbone portion of the animal. It is the rectangular area shown.

"Now, that looks well on paper, true enough," continued the boss with a twinkle in his eye, "but here's the rub: the cross section of a steer's or cow's back is generally about like this (Fig. 2).

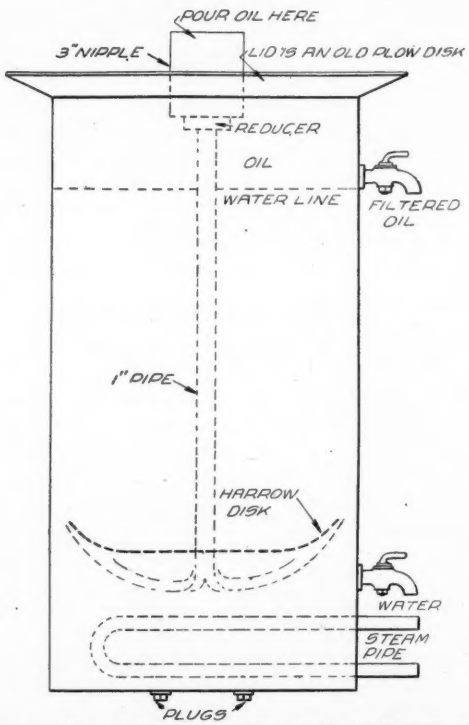
"It curves out and it curves in, you see, and it's mighty hard to see just which curve has the advantage, the 'in' or the 'out' curve. If the critter isn't well fed, I should say the 'ins' have it; if she is well fed, I'll give the decision to the 'outs.'"

It is a fact that the quality portion for belts as shown by the first sketch includes a strip only 15 in. to each side of the backbone. This is in accordance with prevailing belt specifications. My boss's criticism therefore interested me and I thought that perhaps it might interest others.

N. G. NEAR.

Oil Filtering Methods

REPLYING to the communication of F. O. B., page 1041 of the Dec. 15, 1916, issue, I wish to state that I am using filtered cylinder oil from an oil extractor on a deep well pump and all my boiler feed pumps with entire satisfaction.



SECTION OF OIL FILTER MADE OF AN OLD KITCHEN RANGE BOILER

The filter I use is made from an old kitchen range boiler which I purchased at a second-hand store for 75 cents. I cut off the top, plugged the 2 bottom openings and drilled holes for steam pipe and faucets as shown in the accompanying illustration.

An old plow disk is used for cover. Oil is poured into the filter through a 3 by 6-in. nipple attached by means of a reducer to a 1-in. pipe to which, in turn, at its bottom end is attached an old harrow disk.

D. E. C.

Successful Kinks From The Plant

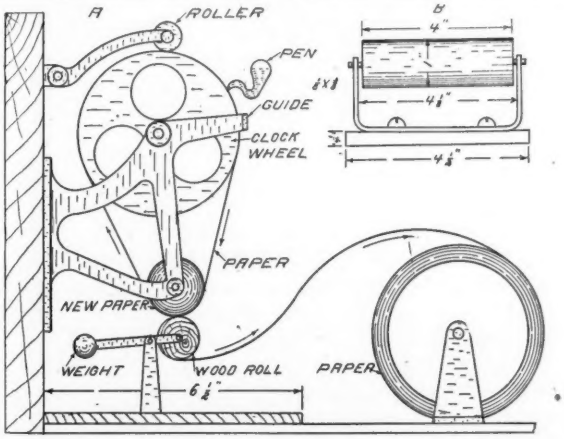
For Saving Time, Work and Trouble

Recording Voltmeter Kink

THE LETTER, Graphic Meter Take-Up Stand, page 1004, Dec. 1 issue, calls to mind a similar experience with 2 curve-drawing volt-meters which gave considerable trouble, due to the clock work stopping caused by the paper being caught by the guide below the pen. The result was that the pen was pushed from the chart and no record made.

Several arrangements were tried to overcome the trouble, but the one shown in the accompanying sketch was the only successful one. It was constructed as follows:

A piece of ⅛ by ⅜-in. brass was bent as shown at (B) and fastened to a 6½ by 4½ by ¼-in. brass plate with 2 brass machine screws. A 3/32-in. hole was drilled near the top of each standard for a pin carrying 2 pieces of ⅛ by 5/16-in. brass about 4 in. long, acting as levers and between which were mounted at one end, a 1-in. wooden roll and at the other end a counterweight consisting of a piece of ⅜-in. round brass. The weighted roll was set in the case below the unused paper roll, and the weight held the empty spool in contact with the



(A) COUNTERWEIGHTED WOODEN ROLLER PLACED AS SHOWN PREVENTED PAPER CATCHING AT GUIDE
(B) CONSTRUCTION OF BRASS ROLLER SUPPORT

paper revolving with it. The free end of the paper was brought over the empty spool and pressed against the moving roll of new paper by the weight. As the clock drum now turns, it unwinds the paper, and due to the friction between the paper and spool draws the marked paper smoothly around the bottom spool thereby preventing interference by the guide.

The weighted spool is not fastened to the case, but is held in place by the heavy base, and can readily be removed if necessary.

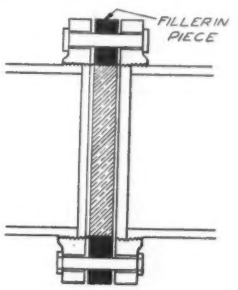
Since this arrangement has been in use, no further trouble has been experienced; it is of neat appearance and costs but a few cents and a little time to make.

In many instruments of this type the paper is pulled around the drum by clockwork applied to the receiving drum, and I am of the opinion that that idea gives better results than where the paper is pushed around the drum, as the latter method is more liable to catch under the pen, especially where the instrument is in a small case.

J. C. HAWKINS.

Joint Made from Companion Flange

WE RECENTLY installed, because of increased load, a 150-kw. engine and generator unit to take the place of an old 75-kw. unit, and as the new unit had to be installed in the same location as the old unit and the replacement had to be made with the least possible delay, we arranged to have all the piping cut and on the ground so that it would be available when needed. This was done, and when we came to run the exhaust pipe from the engine into the header, both fixed and immovable, we found that the length of the two sections



COMPANION FLANGE USED TO EXTEND PIPE LENGTH

of exhaust pipe as made up was about 1½ in. short, after all possible leeway had been taken in account.

Since time was essential and we had no use for the present piece of pipe if it was discarded for another new longer piece, we decided to make a filler piece to fit between the companion flanges at the connection at the middle piece. This filler piece was made by taking a companion flange and planing it off on both sides so that a tight joint would be made on each side and then drilling it to suit the drilling on the other 2 companion flanges. Gaskets were placed on the 2 flange faces and the joint was pulled up with extra long bolts and nuts. This has been in service for several months and has proven entirely satisfactory.

M. A. SALLER.

SOME MEN who don't trust themselves wonder why others won't trust them.—Ideal Power.

Questions Answered and For Answer

Expert Help When In Trouble. If You Want Quick Answer Enclose a Stamp

Coast Artillery Corps Examination Questions

THE FOLLOWING constitutes a portion of an examination recently given by the Coast Artillery Corps, U. S. A., for the position of engineer:

1. What is the average ratio of grate surface to heating surface for anthracite coal? For bituminous coal?

A. In hand-fired plants using anthracite coal under forced draft, 40 to 50 sq. ft. of heating surface to each square foot of grate has been found to give excellent results. Where bituminous coal is burned with natural draft there is variation in the ratio of heating surface to grate surface ranging from 50 to 78 with an average of 60. For stokers used with natural draft, conditions are much as with hand-fired furnaces, and excellent results are obtained with ratios of from 50 to 60 to 1, of projected area.

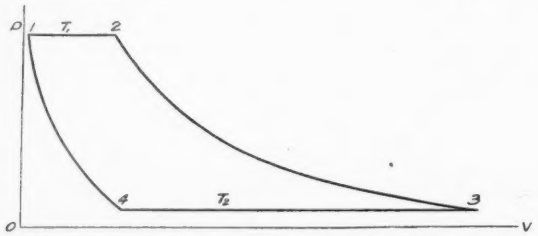


FIG. 1. CARNOT CYCLE FOR DRY AND SATURATED STEAM

2. What is the most accurate way of determining the steam consumption per indicated horsepower of a steam engine? How may the steam accounted for by the indicator be obtained from the indicator diagram? What is the value of such a determination?

A. With a constant load for some given interval such as, let us say, 15 min., determine the amount of steam used by means of a reliable steam-flow meter; multiply this by 4 for the consumption per hour at this 15-min. rate. During this time take a number of indicator cards from which work up the indicated horsepower, using the average obtained. Divide the steam consumption in pounds per hour by the number of indicated horsepower and the quotient will be the consumption per indicated horsepower-hour.

The water rate or steam consumption of an engine may be obtained from the indicator diagram as follows:

Let p = mean effective pressure; l = length of stroke in feet; a = area of piston in square inches; $a \div 144$ = area in square feet; c = percentage of clearance to stroke; b = per cent of stroke at point where water rate is to be computed; n = number of strokes per minute; 60n = number strokes per hour; w = weight of 1 cu. ft. of steam having a pressure as shown by the diagram corresponding to that at the point where water rate is required; w′ = that corresponding to pressure at end of compression.

$$\text{Number of cubic feet per stroke} = l\left[\frac{b+c}{100}\right]\frac{a}{144}$$

$$\text{Corresponding weight of steam per stroke in pounds} = l\left[\frac{b+c}{100}\right]\frac{a}{144}w.$$

$$\text{Volume of clearance} = \frac{l\,c\,a}{14{,}400}$$

$$\text{Weight of steam in clearance} = \frac{l\,c\,a\,w'}{14{,}400}$$

$$\text{Total weight of steam per stroke} = l\left[\frac{b+c}{100}\right]\frac{w\,a}{144} - \frac{l\,c\,a\,w'}{14{,}400} = \frac{l\,a}{14{,}400}[(b+c)\,w - c\,w']$$

$$\text{Total weight of steam from diagram} = \frac{60\,n\,l\,a}{14{,}400}[(b+c)\,w - c\,w']$$

Indicated horsepower is equal to $p\,l\,a\,n \div 33{,}000$. Hence the steam consumption per hour per indicated horsepower is,

$$\frac{60\,n\,l\,a}{14{,}400}[(b+c)\,w - c\,w'] \div \frac{p\,l\,a\,n}{33{,}000} = \frac{137.50}{p}[(b+c)\,w - c\,w']$$

The value of a determination such as this is largely dependent upon instrumental and personal accuracy.

3. Name 8 losses which tend to lower the efficiency of a steam engine.

A. (a) Unavoidable thermodynamic loss; (b) imperfection of cycle employed; (c) imperfection of condensing machinery employed; (d) wire drawing and fluid friction; (e) cylinder condensation; (f) valve and piston leakage; (g) conduction and radiation of heat; (h) and mechanical friction.

4. What is a carburetor? Can kerosene be used in a gasoline carburetor to run a gasoline engine?

A. A carburetor is a piece of apparatus used in connection with internal combustion engines in which the fuel used is evaporated and mixed with the air which forms the remainder of the charge.

Almost any gasoline engine which has been operated long enough to have attained an average working temperature can be made to continue in operation on a kerosene and air mixture formed in a gasoline carburetor. The operation will, however, be more or less uncertain and in general it will be but a matter of a few days

before the interior of the cylinder is covered with a thick deposit of carbon and the piston rings gummed and even burned tight in their grooves. Preheating the air and jacketing the carburetor will generally minimize the difficulty, but will not entirely overcome it.

5. (a) How are reamers made and used?

(b) What is the essential difference between bolt and pipe threads?

(c) What kind of work can be done on a shaper?

A. (a) The reamer consists of a piece of hardened steel, slightly tapering at the end and ground to the exact diameter of the hole it is to make. It is fluted and carries longitudinal teeth after having been hardened.

The hole it is desired to enlarge should not be more than 1/32 in. smaller than the reamer, thus leaving 1/64 in. to be cut on each side. The reamer is fed down into the hole by striking it on the head with a lead or babbit-headed hammer and turned by means of an ordinary bit brace. When using the reamer it is always well to pass the whole tool through the hole.

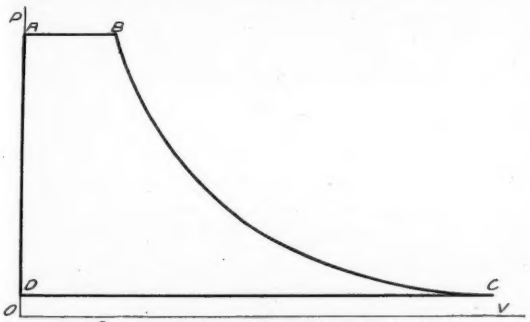


FIG. 2. DIAGRAM OF THE RANKINE CYCLE

(b) The essential difference between bolt and pipe threads is that that on the pipe must of necessity, on account of the comparatively lesser amount of stock, be less in depth than that on bolts.

(c) The shaper is practically a planer for light work, such as the cutting of small key ways, the forming of keys, etc.

6. What is meant by (a) the Carnot cycle and (b) the Rankine cycle?

(c) How is the charge ignited in the Diesel engine?

A. (a) When a substance is caused to undergo a series of processes, for any purpose, and is finally brought back to the thermodynamic state it had initially, the substance is said to perform a cycle. In case the series of processes which the working fluid undergoes in any cycle are all reversible processes, the cycle is said to be reversible.

The simplest form of reversible cycle is that devised by a French engineer by the name of Carnot, and known, therefore, as the Carnot cycle. In this, the working substance undergoes the 4 reversible processes indicated in diagram Fig. 1. First, the substance is caused to expand isothermally at some temperature, T_1, from state 1 to state 2. It is then caused to expand adiabatically from state 2 to state 3, thereby attaining some lower temperature, T_2. It is then compressed isothermally to state 4 and finally compressed adiabatically until it reaches its initial state. Since the several reversible processes may be passed through in reverse order, the cycle itself is a reversible cycle.

A second steam cycle (b) is one which is known as the Rankine, or as often termed, the Clausius cycle. Since this is the most efficient cycle which may be performed by steam without evaporating and condensing the working fluid within the engine cylinder, it has been adopted as the standard of efficiency with which the efficiency of all other cycles may be compared.

The engine is assumed to have no clearance, and the walls of the cylinders to be non-conductors of heat. Steam is admitted from a boiler from point A (see Fig. 2) to point B, the expansion being isothermal and the boiler and steam pipe being a part of the expansion chamber. At B cutoff occurs, and the steam contained in the cylinder expands adiabatically to the pressure of the exhaust pipe, as shown by line B-C, some of it condensing during the process. At the end of this expansion, the steam is discharged into the exhaust pipe at a constant back pressure, line C-D representing this process of isothermal compression. Line D-A represents the rise in temperature and pressure without change in volume which results when the inlet valve opens.

In the Diesel engine, the air is compressed to a predetermined temperature above the firing point of the fuel, which is then blown in as a cloud of vapor, and ignites spontaneously without explosion solely by reason of the heat of the air generated by the compression.

(To be continued.)

Establishing Vacuum in Draft Tube; Discharging Electrolytic Lightning Arresters

How is a vacuum obtained in the draft tube of a water wheel? Is it necessary to use an air pump to secure first a partial vacuum (according to the length of the tube) before or after starting the machine?

2. An electrolytic lightning arrester is normally charged to a potential about equal to that of the line which it serves. In case it becomes necessary to open such an arrester for inspection or repairs, would it first be necessary to discharge it? If so, how is this done?

O. B. E.

ANSWERS

Because of the fact that the submerged end of the draft tube is sealed, the action of the falling water from the turbine tends to create a vacuum in the draft tube which has the effect of sucking water through the turbine. To secure a partial vacuum, the air pump should be used before starting.

2. An electrolytic lightning arrester does not retain any of the voltage which is passed through it and therefore does not need to be discharged before working on it. The voltage is passed through it to maintain a proper film on the electrolyte and as the arrester is properly grounded no static is retained.

W. P.

Correction

In the article entitled Gas Engine Testing, on page 120 of the Jan. 15 issue, a formula given for the determination of the brake horsepower of a gas engine employs a constant 602,432. This, due to a typographical error, is incorrect and should in each instance be 6.2832.

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Afterwards

Public opinion is growing in its determination that in some way this country must be better prepared to defend its rights in the council of world powers. There is still difference of opinion as to how this shall be accomplished, but the fundamental fairness of equality in service both because of the duty every man owes to his country, and because of the benefit to the young men of the country of expressing in material manner their obligation, and thereby fixing firmly in mind the principles of loyalty and service to the nation is coming to be universally recognized.

Events of the last two years are driving home the fact that for successful defense of our soil or our industries there must be readiness to serve not only in the spirit of our citizens, but in plans and organization to make our resources quickly available in case of emergency. Universal service may well mean that some shall give of their time to training for military defense, while others give equal time in part to the necessary preparation for supplying transportation, equipment and supplies which would be needed by the forces in the field. Since emergency may demand that any able-bodied man take his place in the field, it would seem that all should have the fundamental training which will enable them to fit quickly into the field forces, if the emergency calls. After that, the time of each one during his service period may well be given to that public work at which he can be of greatest use during his training period, and afterward if the call for emergency service comes to him.

Details of such a plan must be left to those who will have charge of the work, but the principle of universal service to the country in such way as will be of greatest benefit to the country seems a fair proposition. We have drifted too far in the direction of individual self seeking and must regain the habit of national thinking and the recognition of national duty and unity which were universal in the early days of the republic if we are to continue as a strong nation.

Military and Naval warfare, we hope will not come although well-informed men both in and out of government office are fearful even in this matter. But intense competition in industry—"industrial warfare"—is almost certain as soon as the nations now in conflict are free to give trade development their undivided attention. In fact, England is active now in its preparation to utilize the efficient methods, that the war has forced on its factories engaged in making munitions and war supplies, for industrial competition later. Among the measures are, government buying of raw materials in large quantities to be supplied to manufacturers at low prices; government support and subsidy for fundamental industries such as dye works and agricultural machinery; protection for all manufactures, especially infant industries; training of workers and researches for assisting "key industries" which are of vital importance to the nation; preferential tariffs for the British Empire; reciprocal privileges for British and Allied shipping in ports of allied and neutral nations; marking of all goods sold in the British Empire as "German," "Austrian" or "Not British" according to the country where they are made.

Conferences are being held between employers and workers to plan methods of working together to insure increased production after the war without loss to workers. This is to be accomplished in part by standardization of product and processes, in part by efficient methods of management; but nothing that will contribute to more effective manufacturing and marketing is to be neglected. Combinations of manufacturers are being encouraged to meet foreign competition, especially in the iron, steel and engineering industries.

Like activity is evident in France and Canada, and the news from Germany indicates that the Central Powers are keen to take advantage of the efficiency that has surprised the world to gain all possible trade increase after the war.

Getting all possible out of every resource and using all resources of man power and material has been forced on the warring nations by stern necessity. They are preparing to apply these lessons in the "Afterward" to the struggle for business. We who have been so far spared the grim taskmaster who has driven them to learn their lesson, may well take note of what they are planning; and if we do not work quickly and effectively to prepare ourselves for the industrial struggle, using the methods that they know to be effective, of co-operation and united action, we may well find that the result of our industrial unpreparedness is as disastrous to our industries as would be our lack of defense preparation in case of invasion by a foreign army. The governments, federal, state and municipal, employers and employes, "capital and labor," scientists and artisans should be united in the common effort so to plan and execute that The United States of America may maintain its industrial position as well as its political standing among the nations, and may secure its full share of the world's trade.

Statesmen in England declare that a "Wait and See" policy in regard to industry and commerce after the war is madness. Are we to be mad or sane? The answer depends on the willingness of each individual to put nation before self and to work for national welfare. To secure such willingness is one of the chief ends of a term of universal service during early life.

Editorial Comments

That electric current can be supplied more economically from a large plant equipped with modern machinery, under the supervision of experts, and transmitted considerable distances, than from small generating plants at local distributing points, usually handicapped by lack of labor-saving devices and instruments necessary for securing highest economy, is the contention of central station managers. There are limitations, of course, but for small cities, towns and villages, the centrally located plant with radiating feeders carrying high-voltage current is able to extend electric service to many customers who would otherwise be without it. Such a central plant is described in the leading article of this issue and the equipment and arrangement will be recognized as strictly modern and of the highest class.

Those who do not make a regular practice of going over the boiler setting frequently will find in the article on Economy in the Use of Coal that excess air is the cause of the greatest loss in boiler furnaces; it doesn't all come through holes in the setting, but the opportunity offered here for raising efficiency should not be neglected. Mr. Bement also explains how the CO_2 record helps in locating incorrect firing methods.

Designing thick cast cylinders is not so simple a matter as it might seem; in fact, the formula required represents a great amount of calculating, but with the cleverness of a magician, Mr. Gallo converts the formula into a very simple chart which can be used by anybody desiring to design cast cylinders.

Unaflow engines have not yet been sufficiently demonstrated in practical industries in this country to warrant their installation in many places where reciprocating engines of older types have proved successful; in fact, a number of inherent characteristics limit the field of the unaflow engine, but the lines have not been definitely drawn. The article by Mr. Trink draws quite definite conclusions in regard to the unaflow engine in steel works and represents the results of some pioneer investigations.

Much is yet to be learned in regard to materials used for electric circuits as is evidenced by two articles published in the Electrical Department of this issue. Low-carbon steel for resistance grids is a new departure, but Mr. Thompson points out that it is cheaper than ordinary resistance grids and performs its service satisfactorily. Steel conductors for transmission lines are discussed by Mr. Dwight, who points out that this metal, in some respects, is better than copper for electric circuits. It requires no stretch of imagination to conceive that the most economical and satisfactory electric transmission circuit will be made up of sections of copper, aluminum, steel and other metals yet untried, each section meeting a different condition most satisfactorily.

In recent issues several questions have been raised by correspondents and in the Letters Department of this issue are published comments upon some of these as received from our readers. By this incident we are forced to comment upon the spirit of helpfulness that prevails among engineers. Scarcely a question is brought up for discussion in these columns but that many helpful replies are received. This is the reader's department and you are invited to make the most of it.

When in a pinch for time or money you have solved a mechanical problem successfully, that solution goes under the general term "kink." In this issue are printed some that are worth remembering; they may save you both time and money.

Your examination—will it be next month? Whether or not, you will find some interesting questions and answers published on another page with which it is well worth being familiar, for they present real engineering problems that require more than superficial knowledge to understand. There are also answers given to some operating difficulties which may be bothering you.

In the power plant field new equipment is continuously being presented for consideration and selection; familiarizing yourself with the new devices will make the future for you. Take care of the present, provide for the future and the past will take care of itself.

Power Apparatus in Shop and Market

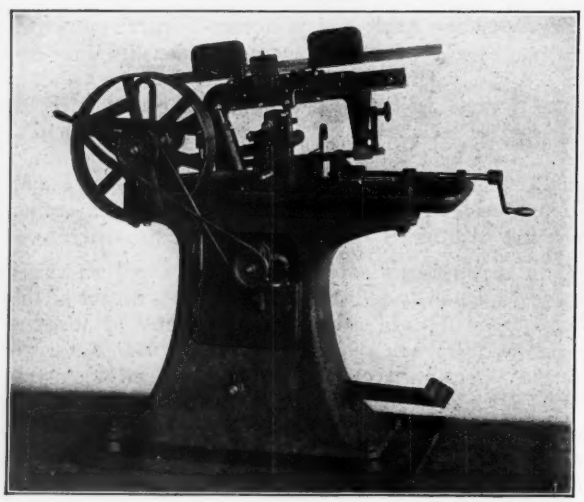
New Ideas In Making, Buying and Selling

New Hack Saw Machine

RECENTLY placed on the market by the L. S. Starrett Co., of Athol, Mass., a new hack saw machine combines a number of features which are intended to give reliable and economical service.

To insure uniform wear of blades and faster cutting, a stroke adjustment is provided which makes possible a stroke of practically the full length of the blade, no matter what the size of stock. Another feature is the foot treadle which raises the saw frame by means of the operator's weight.

Controlling the descent of the saw is an oil dashpot which allows the machine to be started when the frame is up and prevents it from dropping and breaking the saw. Another feature is the automatic locking device



L. S. STARRETT CO. HACK SAW MACHINE

which prevents the saw dragging on the return stroke and holds the saw frame at any height when the machine is stopped for setting work. The saw frame is mounted on a rectangular slide with a bearing 11¼ in. long, accurately fitted with an adjustment for wear, and is provided with a quick-acting saw tightener to hold the blades square. The stroke of the saw is adjustable for stock from 1 to 6 in. in diameter.

Located inside the base are a pump and lubricant tank which may be quickly removed for cleaning, although this is seldom necessary as chips are retained in the pan of the bed and easily removed. The machine is intended to take a 14-in. saw, but a 12 or 13-in. saw may also be used. The height over all is 48 in., and the height to the top of the table is 28 in. The machine occupies a floor space 14 by 32 in.

New Filter Extractor

FORMER models having obtained a positive and thorough filtration and extraction of oil and grease with the multiple filtration principle, it is again employed in an improved type of grease extractor recently placed on the market by the Lagonda Mfg. Co., of Springfield, Ohio.

This new filter and grease extractor consists of 2 chambers, each of which contains a single filtering element in the form of a spool on which a length of Terry linen is wrapped with the layers separated by alternate layers of a wire mesh spacing mat. All of the water is filtered and refiltered through 5 layers of linen filtering cloth, thus obtaining a thorough removal of suspended solids, oil and grease from the boiler feed water. This effective filtration is secured with a minimum drop

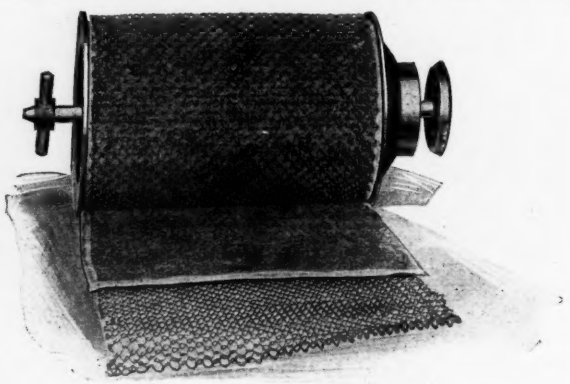


FIG. 1. VIEW SHOWING METHOD OF WINDING TERRY LINEN AND SPACING MAT ON SPOOL

in pressure as the velocity of the water is greatly reduced when entering the large filter chambers.

Gate valves at the inlet and outlet control the chambers which may be cut into or out of service by simply shifting these valves. With the usual method of operation, one chamber is in service at a time, the other being held in reserve so that when it is necessary to clean one chamber, the valves are shifted and the reserve chamber is thrown into service. Thus there is always a continuous supply of clean water furnished to the boilers and no bypass is necessary. Advantage may be taken of the double capacity of the filter in time of overload or unusual conditions requiring more water, when both chambers may be thrown into service giving double capacity.

To clean this type of grease extractor, the fouled linen is unrolled from the spool and replaced with a

clean extra length which is furnished. The filter spool is lifted from the filter chamber by means of a handle at the top of a valve stem, and as the spool is lifted out the valve closes the bottom so that all dirt which has accumulated within the core of the spool is lifted out with the spool itself. When the filter is in operation, this valve is held open by the cover which engages the valve stem.

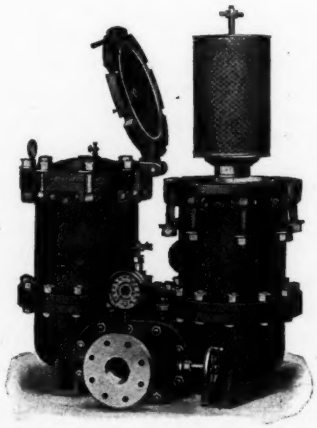


FIG. 2. INLET SIDE OF FILTER WITH SPOOL REMOVED FOR CLEANING

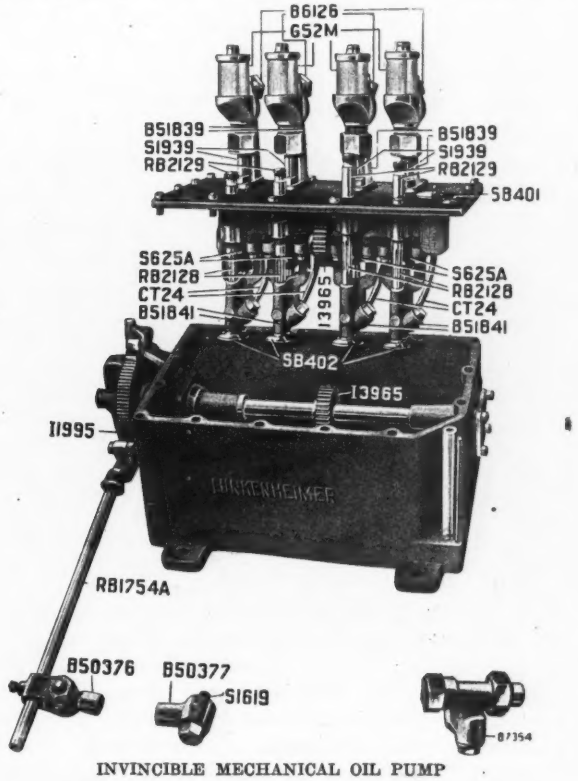
Arrangement for flushing out the filter chambers without removing the cover is provided, pipe connections being located near the top of each chamber for a water supply. Blowoff connections are at the bottom of each chamber.

Recent Design of Mechanical Oil Pump

DESIGNED for the lubrication of stationary and portable steam or Diesel oil engines and air compressor cylinders is a new oil pump in which virtually all parts are attached to the lid, so that upon the removal of the lid, the parts are exposed for inspection or repairs.

Operation is as follows, reference being had to the accompanying illustration: B-50377 is attached to eccentric rod or other moving part of engine and connected to link B-50376 by a rod of proper length. Line check B-7354, threaded for ⅛-in. pipe, is furnished for every oil outlet on pump and is attached as close to the steam pipe as possible. The position of the link B-50376 on rod RB-1754A, governs the arc of travel of ratchet wheel I-1995. Gear I-3965, revolving with ratchet wheel I-1995, imparts motion to pump plungers through the mediums of gear I-3965 on eccentric shaft and eccentrics S-625A. Auxiliary plungers being suitably connected with force pump plungers, move in unison with them. On the up-stroke of auxiliary plungers, oil is drawn through strainers in bottom of holders SB-402, into auxiliary cylinders B-51,481, from where it is forced on downward stroke through tubes CT-24 and passage in parts B-51,839 to sight-feeds G-52M. As the oil drops through the sight-feeds, it is drawn into force pump cylinder on the downward stroke of the plungers S-1939, from where it is forced upon the upward stroke through unions B-6126 to the cylinders to be lubricated. The quantity of oil desired fed is regulated outside the body of auxiliary pump plunger extension stems RB-2129.

Regardless of the level of oil in the reservoir, the lubrication of such parts within the body as constantly require it is automatically taken care of by an arrangement provided at the bottom of the force pump plunger. Every outlet is provided with a sight-feed and independent feed regulation and they can readily be adjusted without



INVINCIBLE MECHANICAL OIL PUMP

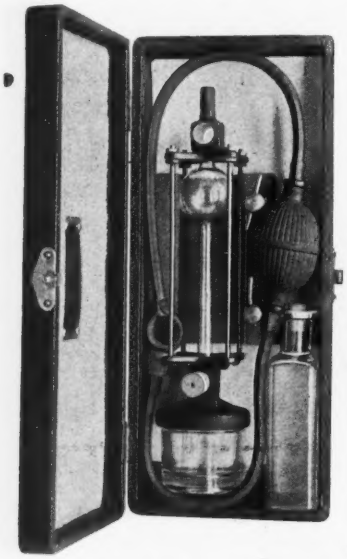
the use of tools or the removal of any of the parts. A sliding cap, to prevent dirt from entering, is provided on the filling hole and within the opening is a bronze strainer which can readily be removed for cleansing.

The Lunkenheimer Co., of Cincinnati, Ohio, is the maker of this new pump, which is given the trade name "Invincible." It can be had with from one to 4 feeds—the one-feed having a capacity of one quart or half gallon, the 2-feed, half gallon or one gallon, and the 3 and 4-feed, one gallon.

U. S. CIVIL SERVICE COMMISSION announces an examination for mechanical laboratorian, on Feb. 7 and 8, to fill 2 vacancies at $4.24 a day at the Naval Engineering Experiment Station, Annapolis, Md. The applicant must show that he has graduated from a 4 yr. course in mechanical engineering from a college or technical school of recognized standing; or that he is a senior student in such an institution and expects to graduate within 6 mo. from the date of the examination; or that he is a graduate from a 4 yr. high-school course or has had 4 full years of study in a school offering a course equivalent to that of a high school and has had in addition 2 yr. of experience. Apply for Form 1312.

Pocket CO_2 Indicator

FOR checking the completeness of combustion in a furnace, no other determination is so significant as the amount of CO_2 in the flue gases. The difficulty ordinarily encountered in making this determination has been a handicap to its universal employment in boiler rooms of power plants, but an instrument known as the



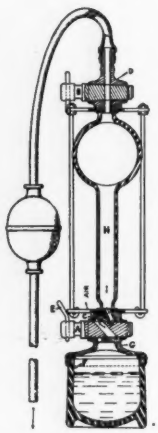
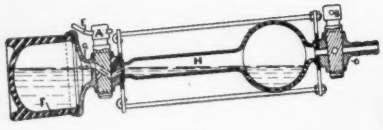


FIG. 1. POCKET CO_2 INDICATOR IN CARRYING CASE
FIG. 2. INSTRUMENT IN POSITION FOR TAKING SAMPLE

Pocket CO_2 Indicator has recently been developed by the Bacharach Industrial Instrument Co., which makes the taking of an analysis a simple matter, thus making it possible for plants of all sizes to avail themselves of the advantages gained by a knowledge of existing combustion results. The instrument is always ready for use,



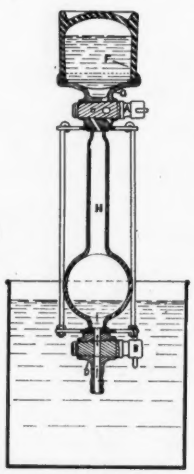


FIG. 3. EXPOSING GAS SAMPLE TO ABSORBING SOLUTION
FIG. 4. DRAWING WATER INTO MEASURING TUBE

can be operated by an inexperienced man, is of small size, making it convenient to carry around, and requires no auxiliary apparatus.

When preparing to make a CO_2 determination, after taking the indicator out of the case, the rubber stopper is removed and the 2 cocks, A and B, are put into their places. The glass jar, F, at the lower end, is then removed from the metal body, C, and filled with the analyzing solution, after which it is screwed on again. With the pump attached to the open upper valve, D, and the cock of the lower valve, A, turned, so that the glass measure tube, H, in the center is open to atmosphere through hole c, the indicator is ready for use (Fig. 2).

The glass jar, F, having once been filled with KOH (sodium hydroxide), the open end of the pump is connected to the gas line from which a sample is to be taken. The gas is now pumped in, at the same time allowing the air to escape to the atmosphere through hole c (Fig. 2). When a fair sample of gas has been collected the upper cock, B, is closed.

The lower cock, A, is then turned 180 deg. to permit the gas and KOH to come in contact for chemical action, helping the process by holding it inclined downwards and shaking it (Fig. 3). When the solution has been drained back to the glass jar, F, the lower cock, A, is closed and the indicator held vertically upside down and immersed in water (Fig. 4). The submerged cock, B, is opened and the ingoing water which takes the place of the absorbed CO_2 is leveled with that outside. The cock, B, is then closed and the indicator brought to its base. Opening cock B, the per cent of CO_2 is read off on the tube at the water level. Turning the apparatus upside down, the water will run out through the open cock, B, and the instrument is ready for another determination.

New G. E. Demand Meters

DEMAND METERS are in connection with watthour meters and according to type either indicate or record graphically the maximum demand over a definite time interval.

Types M-4 and G-2 as made by the General Electric Co. operate on the same general principle and are furnished for use with either alternating current or direct current watthour meters.

Their 2 essential parts are demand registering and timing mechanisms connected and mounted in the same case. The demand registering element, for all types, is electrically driven from the register of the watthour meter in which is mounted a contact device. This consists of a small contact-making cam, of insulating material and 2 parallel leaf-springs, equipped with platinum iridium contact points. Rotation of the cam by the watthour meter closes the circuit through the electric magnet coil of the indicator and operates the registering mechanism as described below.

When the contact device closes the circuit through the magnet coils of the demand meter, the armature of the electro magnet is attracted and moves forward engaging the pawl at its end with the ratchet wheel turning the latter. When the contact device opens the circuit a spring returns the armature lever and pawl to their original position. The motion of the ratchet wheel is transmitted through gearing to the stylus or the pointer, as the case may be, moving it forward for each closing of the circuit until the end of the time interval is reached. At this point, a cam driven by the timing element has rotated to such a position that a

trip lever disengages a sliding pinion from the gear with which it meshes, thus opening the gear train and allowing a spring to return the stylus or pointer advancing mechanism to the zero position. Further rotation of the cam returns the sliding pinion to its former position and re-establishes the gear train. The mechanism is now in a position to measure the energy consumption during the next time interval.

In the operating mechanism, the Type M devices differ from the Type G in the return mechanism oper-

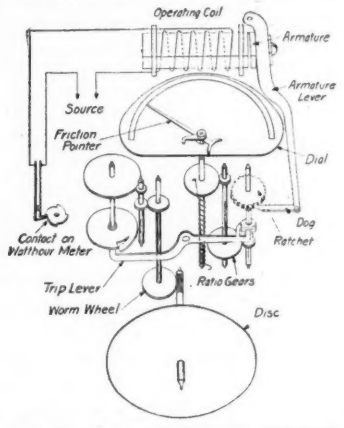


FIG. 1. DIAGRAM G. E., TYPE M DEMAND METERS

ating at the end of each interval. With the indicating type it is not necessary to keep absolute time and the mechanism is simplified on this account, leaving a short interval of time between each measurement. That is, there is an interval between the end of each time interval and when the device begins to record for the next time

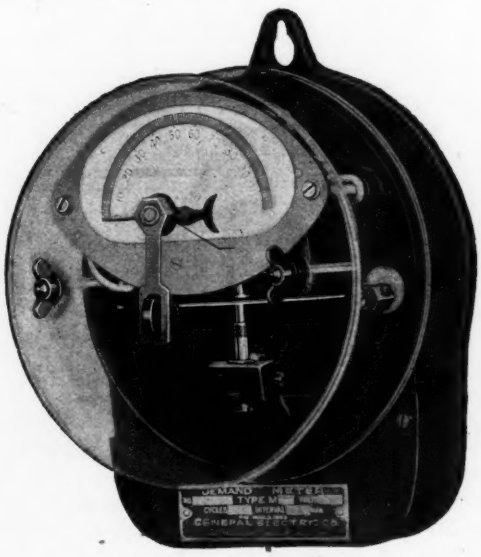


FIG. 2. G. E. TYPE M-2 DEMAND METER

interval. With the Type G graphic device it is, of course, necessary to keep the chart running to exact time. Therefore, there must be no lag between intervals and the return mechanism is so arranged that the unmeshing of the gear train and re-engagement for measurement of the next interval is practically instantaneous. In addition to this difference in the operating mechanism, all parts in the graphic device are made much heavier on account of the increased torque, necessary to operate the marking stylus as compared with the pointer on the indicating device.

In the graphic device the timing mechanism needs attention only when the paper is renewed and a time setting disk is provided to synchronize the chart with the correct time.

These charts are arranged to cover one week and the divisions show the current consumption hour by hour and day by day, during that period. The record takes the form of a saw tooth polar curve and the distance of the extreme points of the curve from the zero lines of the chart indicates the demand in kilowatts.

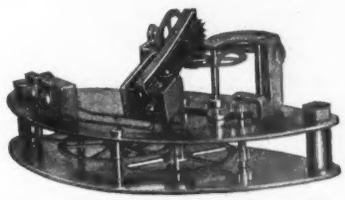


FIG. 3. TYPE D-2 CONTACT MOUNTED ON 1-14 WATTHOUR METER REGISTER

The dials and charts may be made direct reading or 100 division dials and charts may be used with all devices, and a constant used, depending on the capacity of the watthour meter with which the meter is used.

All types are made for 6, 18, 110 or 220 v. capacity direct current and for 25 or 60 cycles alternating current, 110 or 220 v. The time interval is 15, 30 or 60 min., as specified. For operation on 440 v. alternating current circuits a small transformer can be furnished to transform to 110 v., 25 or 60 cycles.

Simplex Traveling Grate Stoker

IN order to eliminate grate links subjected to the driving strain of the stoker and the loss of fine fuel, and to obtain a uniform, level grate surface which cannot distort or sag, a continuous and uniform forward movement of the grate, and a uniform and equal distribution of air, the James A. Brady Foundry Co., Chicago, has produced the Simplex Traveling Grate Stoker.

The operating mechanism shown in section herewith is made up of cast iron side frames supporting the front and rear driving gears upon which rides a chain of semi-steel links. To each of these links is secured a steel tee beam carrying a cast-iron grate bar, the length of which is equal to the width of the furnace.

The grate bars are of unusual rigid construction, having 2 steel rods imbedded their entire length near their front and rear edges, so that, regardless of how often or in what manner they may become broken, it will in no way interfere with their usefulness.

As may be seen in the accompanying illustration, the chain tensions are located at the front, easy of access and not requiring the stoker to be withdrawn to make adjustments. The geared reduction drive is mounted upon the front axle bearing, so as to be self-adjusting when the grate tension is taken up or released.

Supply or depth of fuel upon the grates is regulated by an adjustable cast-iron grate lined on the inner side with standard 9-in. firebrick held in place by renewable cast-iron shoes.

Due to the close proximity of the high heated side walls and other influences, it is found that coal fired on

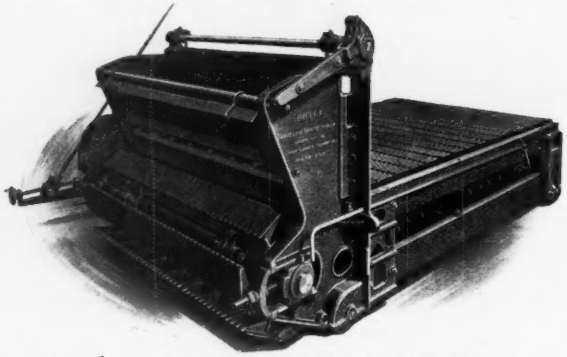


FIG. 1. THE SIMPLEX TRAVELING GRATE STOKER

chain and traveling grate stokers tends to burn considerably faster along the sides approaching the rear, or fuel being carried over the rear throughout the central portion. To correct and compensate for this detrimental feature, the coal feed gate has been designed to permit

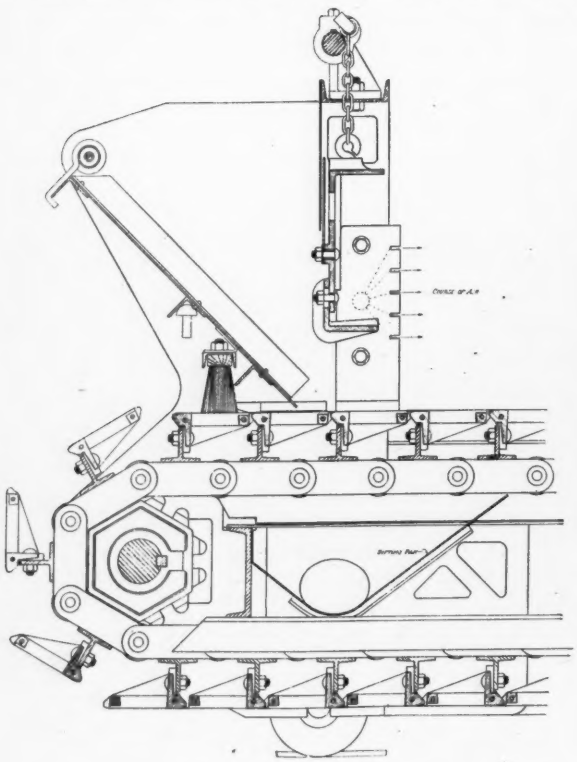


FIG. 2. DETAILS, SIMPLEX TRAVELING GRATE STOKER

a greater amount of fuel to be fed to the grate surface along each side, so that by the time it reaches the rear of the furnace, the fire line is even.

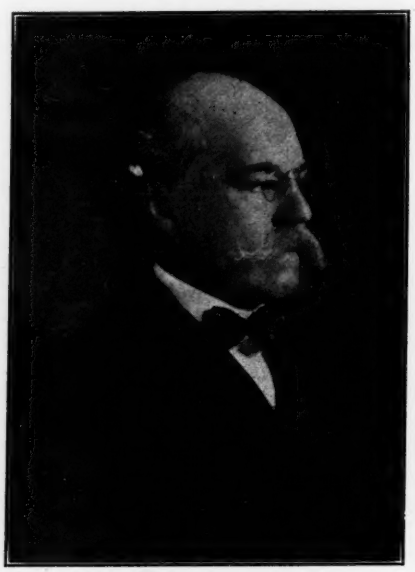
Inserted in each side frame forming the inner sides of the coal hopper, are renewable cooling plates. The front of the hopper is constructed of heavy reinforced sheet metal and is held in normal position by forged hooks at the top. Near the center, it rests upon trunnions permitting it to be easily and instantly brought to a horizontal position should it become necessary or desirable to remove the coal from the hopper, dump the fire quickly, break up a banked fire or permit of hand firing.

The small amount of fuel which may find its way between the grate bars is caught in a shifting pan placed between the advancing and returning racks of grate bars. From here it may be readily removed and returned to the hopper. With the larger size stokers, a worm gear is provided for this purpose.

Alfred B. Jenkins

ALFRED B. JENKINS, president of Jenkins Bros., died at his late residence in Llewellyn Park, West Orange, N. J., on Friday, Dec. 29, 1916.

He was a son of Nathaniel and Mary Tucker Jenkins, and was born in Boston, Mass., on Nov. 25, 1848. The business in which Alfred B. Jenkins was so vitally interested for upwards of 40 years, was founded by his father, Nathaniel Jenkins, who in 1864 first interested himself in the invention of water faucets, and opened a place of business at 52 Sudbury St., Boston. Nathaniel Jenkins had conceived the idea of having his faucets fitted with renewable packings of rubber. To make these



faucets satisfactory to his customers and users, he soon found it would be necessary to have the packings made of a material which would stand hot water service. Compositions which would withstand any degree of heat were then unknown, and rubber manufacturers to whom he applied informed him that such packing could not be had.

As he could not purchase, he decided to manufacture. He went to the public library, and made a study of rubber and methods of mixing compounds, and installed,

in one of the lofts at 52 Sudbury St., a rubber vulcanizer and other necessary apparatus. After several years of experimenting, he invented a rubber compound which would not only stand hot water, but also steam. While achieving a satisfactory packing, he also invented a steam valve, and obtained a U. S. Patent thereon in 1866, as well as several medals and diplomas from the Massachusetts Charitable Mechanics Institute. The faucets then had little attention, as all his efforts were now devoted to the production of a valve for steam service, and the manufacture of packing suitable for steam and hot water joints.

During 1866 and 1867, several additional U. S. Patents were granted him for inventions or improvements in valves and packing, and, after various types had been tried, he invented, and in October, 1868, obtained a patent on the type of valve which is now known all over the world as the Jenkins valve.

The corner stone having been laid, the next step was the introduction of the goods. With very little capital and an entirely new field of business and with very few acquaintances in the trade, it is not surprising that slow progress was made at the start.

In 1868 Charles Jenkins was taken into partnership with his father, and so continued until the death of Nathaniel Jenkins in 1872, when, to continue the business, his two sons, Charles and Alfred B. Jenkins, formed a co-partnership under the firm name of Jenkins Bros.

Their store was then located at 104 Sudbury St., Boston, and it was there that Alfred B. Jenkins first commenced to sell valves. It was an uphill fight from the start, as the valves were a novelty to the trade, and it had to be demonstrated that the discs would successfully withstand steam. Having early decided that the valves should be of superior quality, and adopting a strong guarantee of satisfaction to the user, with the persistent efforts of Alfred B. Jenkins, who did most of the traveling and selling at that time, it was not long before the valves received the indorsement of users, and the sale increased.

On May 1, 1880, their first branch store was opened in New York; in 1885 a branch store was opened in Philadelphia; and in 1886 a branch was opened in Chicago.

The partnership existing between Charles and Alfred B. Jenkins was terminated in 1896, when Alfred B. Jenkins became sole owner of the business of Jenkins Bros., and continued to trade under the old established name.

To take care of the Canadian business it was deemed advisable to have a factory in Canada, and in 1906 Jenkins Bros., Limited., was incorporated under the Laws of the Dominion of Canada, and a modern factory erected in the City of Montreal. A number of the employes of Jenkins Bros. were given the privilege of subscribing to the capital stock of the new company, and the balance retained by Alfred B. Jenkins.

In the year 1907 the business of Jenkins Bros. in the United States was incorporated under the same title. A portion of the stock was distributed among his employes, while Mr. Jenkins remained at the head as president, and so continued up to the time of his death.

News Notes

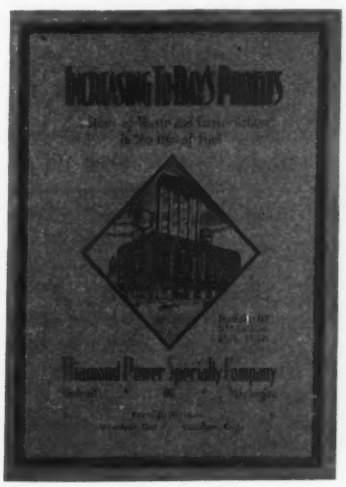
BOUND BROOK OIL-LESS BEARING CO., of Bound Brook, N. J., sends notice of the death of the president and treasurer, William Winsor Smalley, on Dec. 27, 1916.

ANDREWS-BRADSHAW CO., sales engineers, with offices in Pittsburgh and Chicago, established Jan. 1, 1917, a new office in the Leader-News Bldg., Cleveland, Ohio; R. B. Clapp, manager.

U. S. CIVIL SERVICE COMMISSION announces an examination for second class (or assistant) steam engineer, on Feb. 7, to fill a vacancy in the position of assistant engineer, State, War, and Navy Department Building, Washington, D. C., at $1000 a year, but from the register of eligibles resulting from this examination certification will be made to fill future vacancies as they may occur in the Departmental Service at Washington at salaries as high as $1200 a year. The following subjects will have the relative weights indicated: Letter writing (a letter of not less than 150 words on 1 of 2 given mechanical or electrical engineering subjects), 10; practical questions in mechanical and electrical engineering (comprising the construction and operation of the heating plant and electric lighting and elevator machinery in first-class public buildings), 65; training and experience in the maintenance and operation of steam and electrical machinery, 25. Applicants must have reached their twentieth birthday on the date of the examination, and must submit to the examiner on the day of the examination their photographs, taken within 2 yr. Apply for Form 1312, to the U. S. Civil Service Commission, Washington, D. C.

Catalog Notes

INCREASING TODAY'S PROFITS is the title of an attractive catalog recently published by the Diamond Power Specialty Co. The book is well illustrated with



halftones and line drawings and sets forth the advantages of mechanical soot blowers in the operation of boilers.

CATALOG NO. 28, which has just been issued by the Penberthy Injector Co., Detroit, Mich., contains valuable data on injectors and in connection with all jet apparatus, and illustrates a complete line of brass specialties pertaining to steam, plumbing and automobile accessory trades. A copy will gladly be sent to anyone interested.

SPRACO EQUIPMENT, Bulletin No. 250, of Spray Engineering Co., 93 Federal St., Boston, Mass., illustrates and describes the company's equipment for washing and cooling the ventilating air for steam turbine-driven generators.

FROM NATIONAL TUBE CO., Pittsburgh, Pa., we have received a new folder describing the "Kewanee" flange union and illustrating the value of the brass and iron ball joint seat.

THE 1917 PAD CALENDAR of The Wm. Powell Co., Cincinnati, was recently received at this office.

Trade Notes

HOMESTEAD VALVE MFG. CO., Inc., Pittsburgh, Pa., has appointed the following agents to represent the company in their immediate vicinities: Seeger-Walraven Co., Atlanta, Ga.; Joplin Supply Co., Joplin, Mo.; Geo. T. Matthews & Co., St. Louis, Mo.

JAN. 11 TO 13, the annual convention of sales and factory organizations of the Chicago Pneumatic Tool Co. was held at the Great Northern Hotel, Chicago, the program including a trip to the company's plant at Chicago Heights, and concluding with a banquet on Saturday evening. December 31, 1916, closed the biggest month and the biggest year in the history of the business of the company.

BY THE OPENING of the new office at 911 Walnut St., in Des Moines, Ia., on Jan. 1, H. W. Johns-Manville Co. increased the total number of its branches to 55, covering all important cities in North America. Wm. B. Roberts, who has been in charge of the Iowa sales for a number of years, has been appointed manager of the new branch office, with a corps of salesmen and construction men to give Johns-Manville, man-to-man service throughout that section.

UNAVERSOL SUPERHEATER CO., a Michigan corporation, has recently been formed by a number of Detroit capitalists to manufacture superheaters for power and industrial purposes; also other patented steam and fuel saving devices. E. A. Geoghegan, who recently resigned as vice-president, director and mechanical engineer of Superno Co., has accepted the position of chief mechanical engineer to the Unaversol Superheater Co. of Detroit.

THE GEORGE T. LADD CO., of Pittsburgh, Pa., calls attention to the fact that the name of the boiler, which was originally the Milne, has been changed to the Ladd water tube boiler, the reason for this being that since the purchase of the Milne patents some years ago, further developments along original lines have been made with regard to the development of a new design in settings, feed boxes, and many other details to the extent that the majority of the patents now being utilized have been taken out by the Ladd Co. Accordingly the change of the name is warranted.

PRACTICAL ENGINEER

Trade-mark, Reg. U. S. Pat. Off.

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Advertisements in this section are inserted under regular headings.

No display type allowed, but the first three words may be set in capital letters.

About nine words make a line. Minimum space sold, two lines.

Under classification "Position Wanted," advertisements not exceeding four lines will be inserted once for subscribers free of charge.

All copy should be received at Chicago office 18 days before date of publication.

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Position Wanted

POSITION WANTED—I am a thoroughly competent power plant engineer, accustomed to handling on high efficiency basis all types of steam engines and turbines, a.c. and d.c. machines, strictly sober. 34 years old, married. Want charge of good plant in Chicago that will pay at least $25.00 per week. Address Bor 455, Practical Engineer, 537 S. Dearborn St., Chicago. 1-15-2

POSITION WANTED—By engineer 30 years old, married; 7 years' experience with Corliss and high speed engines, refrigeration and d.c. generators. Address Lee McCallum, 512 N. Park, Cadillac, Mich. 1-15-2

POSITION WANTED—I am a thoroughly competent power plant engineer, accustomed to handling on high efficiency basis all types of steam engines and turbines, A.C. and D.C. machines; strictly sober; 34 years old, married. Want charge of good plant in Chicago that will pay at least $25.00 per week. Address Box 455, Practical Engineer, 537 S. Dearborn St., Chicago. 2-1-1

POSITION WANTED—As chief engineer in industrial plant, Missouri, Arkansas, Kansas, Iowa or Nebraska, or as Superintendent of light and water plant in city of 2500 to 8000. Ten years' practical experience with steam, electrical and water systems. Technical training. Now employed by U. S. Government as engineer and instructor. Executive ability. Can report on 15 to 30 days' notice. Married. Age 30. Address Practical Engineer, Box 466, 537 S. Dearborn St., Chicago, Ill. 2-1-1

CHIEF ENGINEER wishes to relocate. Now in charge of 15,000 k.w. railway plant. Eight years experience operating turbines, engines, tubular boilers, with stokers, direct and alternating current generators, also refrigerating machines. Best of references. E. D. D., 1517 Military Ave., Omaha, Nebr. 2-1-1

Help Wanted

WANTED—Resident subscription agents in the following cities: Atlanta, Ga.; Cincinnati and Columbus, Ohio; Kansas City, Mo.; Los Angeles, Cal.; Louisville, Ky.; Newark, N. J.; New Orleans, La.; Portland, Ore.; St. Louis, Mo.; San Francisco Cal.; Washington, D. C. This is an excellent chance for a hustler who is familiar with power plant conditions, to turn his spare time into dollars. To such a one we offer a Real Opportunity. Write Subscription Department, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. tf.

Wanted

WANTED—Agents handling engine and boiler room specialties in every section fo· side line paying large commissions. Give experience, line carried and territory covered. Boy 381, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. tf.

FOUR COPIES of Practical Engineer for February, 1910, in good condition; we will extend your subscription for three months. Circulation Department, Practical Engineer, 537 S. Dearborn St., Chicago, Ill.

WANTED—Agents on commission to sell our shaking grates. We will install grates on trial or put it on test at our expense with any grate made. Address Armstrong Mfg. Co., Springfield, Ohio. tf.

MARINE BOILERS WANTED—From 50 to 250 horsepower. We will pay cash awards for information that leads to a purchase. The Fittsburgh Boiler & Machine Co., Pittsburgh, Kans. 1-1-6

WANTED—A full set of International Correspondence School volumes on Steam and Mechanical Engineering and on Electrical Engineering. Must be in good condition. State price in first letter. Address Practical Engineer, Box 467, 537 S. Dearborn St., Chicago, Ill. tf.

WANTED—One geared belt-driven boiler feed pump to supply 150 hp. boiler. Address Paul O. Moratz, Bloomington, Illinois, stating make, condition and price. 2-1-1

WANTED TO BUY—One steam boiler feed pump for about 100 hp. boiler, 125 lb. pressure. Must be in good condition. Address Pecatonica Elec. Light Co., Pecatonica, Ill. 2-1-1

For Sale

MOTOR FOR SALE—One 40 hp., 850 r.p.m., 220-volt—three phase—60 cycle, Type BP Wagner Motor, complete with compensator, rails and pulley. Motor is in first class condition, ready for immediate shipment. A. L. Swanson Co., 316 2nd St., Evansville, Ind. 2-1-1

GENERATING PLANT FO RSALE—550 d.c. generating plant, in first class condition, which we will sell at a very low price, together with boiler, switchboard and everythinig complete. M. K. Frank, Frick Bldg., Pittsburgh, Pa. 2-1-1

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PATENTS—H. W. T. Jenner, Patent Attorney and Mechanical Expert, 606 F St., Washington, D. C. Established 1883. I make a free examination and report if a patent can be had and the exact costs. Send for full information. tf.

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ENGINEERS, DO YOU WANT to utilize your exhaust steam for heating or drying purposes without back pressure on your engine? If so, address Monash Engineering Co., 1413 W. Jackson Blvd., Chicago, Ill. tf.

Sparks From The Advertising Pages

Get On Your Mark

Get Set

Go!!

Right where you stand is your mark, and having found it—keep your thoughts on the goal ahead but get started right—in other words, "get set," for much depends on getting the right start.

Started right, the rest is up to your "staying qualities" and your ability to see the opportunity where an extra "sprint" will put you ahead of the rest.

"Go"—there's a world of thought and action in that little word. If it's uphill "Go." If it's over hurdles "Go." Only if it's down grade will you find inertia sufficient to propel you automatically. Races are not run on down grades. Brain and Brawn do not win on such a course. But it's where strength is taxed—where mentality is tested that merit wins.

Trained right, you needn't worry. Speaking in facts rather than figures, you need not fear the inroads future steam power plant practice will make on present methods and means if you keep pace with or a litle ahead of present practices.

If you have read and studied engineering literature, both editorial and advertising—if you have posted yourself on power plant equipment—if you know what the engineering market has to offer the buyer of power plant equipment—if you know your plant, its needs and opportunities for development, you need not worry about the last lap — you'll reach it a successful man.

All these qualifications fused into one constitute your ability, and as the course laps around this year all phases of your ability will be brought into play, so,

Get On Your Mark

Get Set

Go!!